METALLURGIA

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The Use of Special Non-ferrous Metals and Alloys in Marine Engineering and Shipbuilding

By J. W. Donaldson, D.Sc.

IN a recent autumn lecture[1] to the Institute of Metals, Mr. F. G. Martin dealt with the uses of non-ferrous metals in the shipping industry. He stated that for a cargo ship of 10,000 tons deadweight, propelled by engines of approximately 6,000 h.p., the proportion of non-ferrous materials in use were relatively small. In the case of reciprocating machinery, out of a total weight of 176 tons (boilers, etc., excluded) only 7·7 tons, or 4·25% of the material could be classed as non-ferrous. For turbines of the same horse-power, where the weight, excluding boilers, etc., is considerably less, amounting to 67 tons, a higher percentage of non-ferrous metals—namely, 6·25—is in use, principally in the form of blading material, which amounts to 3·5 tons or 5·0% of the total. In a Diesel engine of a similar horse-power the weight of the main engines, auxiliary engines, and other fittings is considerably greater, amounting to 1,400 tons. Of this weight only some 62 tons, or 4·3%, are represented by the various non-ferrous materials.

(By courtesy of J. Stone & Co., Ltd.).

One of the four "Turbiston" bronze propellers fitted on R.M.S. "Mauretania." Casting weight, 31 tons; finished weight, 18½ tons. Diameter, 16ft. 9 in.

The proportion of materials used in marine engineering and shipbuilding, which can be classed as non-ferrous, is therefore small when compared with the amount of ferrous materials used. They represent, however, a very important proportion, and for certain parts their uses are essential. The principal non-ferrous metals are copper for tubes, pipes, and sheets, and for electrical purposes in the form of wires and cables; zinc in the form of slabs for boiler corrosion, as plates for propeller corrosion, and for galvanising, and lead for the sheathing of cables. The more common brasses and bronzes are used for a variety of purposes, such as 70 : 30 brass for condenser tubes, rolled naval brass for valve spindles, couplings, nuts, sheets, tubes, and plates; bronzes or gunmetals for such parts as tail-shaft liners and high and low-pressure steam fittings. Special bronzes, such as phosphor bronze and manganese bronze, are also used to a fair extent, the former for turbine construction, electrical purposes, and bearings, and the latter in the manufacture of propellers, valve spindles, and pump rods. White bearing alloys of tin, antimony, and copper with or without lead are used for all types of bearings, and form a large proportion of the non-ferrous alloys used in marine engineering.

These metals and alloys may be considered the standard non-ferrous materials used in the shipbuilding and marine engineering industries. During recent years, however, other non-ferrous metals and alloys have been introduced for special purposes. The principal reason why non-ferrous materials are used to the extent they are in marine work is their resistance to corrosion when compared with ferrous materials, and particularly to sea-water corrosion. Research work on corrosion had led, during the last decade, to a better understanding of the nature of corrosion, and means for its prevention, and the result has been the development of new non-ferrous materials. The development of the internal combustion engine has also brought about certain metallurgical problems, such as scaling, oxidation, resistance to temperature stress, corrosion by oil, etc., and the utilisation of special non-ferrous alloys has, to a certain extent, assisted in solving these problems. A third consideration is that of weight, not only in naval work, where the saving of weight is essential, but also in mercantile work, where less weight means greater carrying capacity and better stability. In this respect the development of the light aluminium alloys of improved mechanical properties have been of considerable advantage, and their use is extending.

Alloys for Corrosion.

Corrosion is one of the most serious problems which marine engineers have had to contend with for many years, and large sums of money and much time have been devoted to investigations both to determining the causes of corrosion and also to devising means for its prevention. One of the most serious and expensive forms of corrosion met with is condenser tube corrosion. This form of cor-

rosion has been a problem ever since the introduction of steam, but the increase of temperatures and pressures due to marine engine development and the increase of water velocities have accentuated it considerably during the last thirty years. In 1910 the Institute of Metals appointed a corrosion research committee to investigate this problem, and the result of their researches has led to a general acceptance of the nature of corrosion, the types of corrosion that occur in condenser tubes, and the development of new materials to prevent or diminish it.

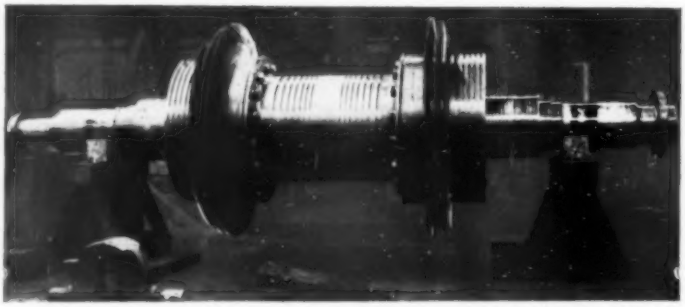
Corrosion is now considered to be of an electrochemical nature. In marine condenser tubes manufactured of Admiralty brass, the copper-zinc-tin alloy most generally used, it attacks the tubes either in the forms known as "dezincification," "deposit attack," or "impingement attack." It has been shown that so-called "dezincification" is not produced by the removal of zinc, but by the re-deposition of copper from a solution of copper and zinc in sea water, and as copper does not form a protective film, corrosion of the tube continues until it is perforated. "Deposit attack," a form of copper-oxide pitting results from the presence of foreign materials in the tubes, and "impingement attack" is the result of the high water speeds in modern condensers, whereby the impingement of small air bubbles destroys the surface films which would otherwise afford a protection to the tubes. To avoid those different forms of corrosion, a condenser tube must be protected by a film of some sort or other, a film which will act as an insulator and prevent the flow of electricity from the sea-water to the tube and vice versa. This film must be strong and adherent, so as to resist the erosive influences existing in the tube, and must be capable of regenerating or rehealing itself if it is broken or destroyed. An apparatus has been developed by May[2] for testing the resistance of such films. In his jet test apparatus a piece of tube is suspended in sea-water, and a jet of sea-water impinged on it and the film potential measured. With such an apparatus it is possible to compare the film-forming properties of various alloys.

Alloys which have this film-forming property to a high degree are the alloys of copper and nickel, and the alloy developed recently by the British Non-Ferrous Metals Research Association, known as aluminium brass.

The copper-nickel alloys which have been found to be most satisfactory are the 80 : 20 and the 70 : 30. Those alloys are both strong and resistant to sea water, particularly the latter, and as they do not contain zinc, tubes manufactured from them do not suffer from "dezincification." Another advantage is that they are not liable to "season cracking," which is frequently a cause of failure in brass condenser tubes which have not been suitably manufactured. In service the 30% nickel alloy has been installed by the Admiralty, and it is also used for tubes by many large British, American, and Continental shipping firms.

Aluminium brass, an alloy containing 76% copper, 22% zinc, and 2% aluminium, and having a good strength and a high ductility, has been found to be very suitable for condenser tubes. It can be worked hot or cold, and when cast by a suitable process, billets satisfactory for tube making can be obtained. In sea water a strong continuous adherent film of aluminium is formed, an oxide which is very refractory, and which is also a good non-conductor of electricity. This film, if destroyed, is capable of regenerating itself or of self-healing, and when tested by the jet method, aluminium brass shows a rapid rate of film formation, regeneration after abrasion is rapid, and after severe jet impingement resistance is extremely good; whereas 70 : 30 brass shows a slower rate of film formation, partial regeneration after abrasion, and a complete breakdown after severe impingement. Tubes of this material are now being fitted in a number of ships.

Monel metal, an alloy of 68% nickel, 29% copper, and 3% manganese and iron, with small and carefully controlled quantities of carbon, sulphur, etc., and which combines the strength and hardness of nickel with the toughness of copper, and the resistance to corrosion of both metals, is also used in the manufacture of condenser tubes. On account of its strength, 40 to 45 tons per sq. in., tubes are manufactured in 20-gauge instead of 18-gauge,



(By courtesy of Mavel-Weir, Ltd.)

One of the Turbine Rotors on the ss. "Bremen." All the reaction blading in this vessel, amounting to about 15 tons, is of Monel Metal.

and this allows of a weight reduction of 25%, which is a considerable saving where the question of weight has to be taken into account. This metal has been used by the Admiralty, and is also in use both in Britain and America in mercantile work. A synthetic alloy of nickel and copper, containing 70% of nickel and 30% of copper, has properties somewhat similar to Monel metal, and is also used in the manufacture of condenser tubes.

Another method which has been adopted for the protection of condenser tubes, and which involves the use of a non-ferrous metal is chromium plating. Metallic chromium is deposited on the inside, or sea-water side, of a condenser tube, and acts as a protection to the tube. It has been stated that such tubes at normal temperature and normal water speeds show an increase in thermal conductivity of 20%. Admiralty brass tubes coated with chromium to the depth of 0·0005 to 0·001 in. are at present being tried by the Admiralty.

In Table I. is given the various alloys experimented with by the Admiralty for condenser tubes. These are taken from a recent paper[3] by Captain J. Hope Harrison. This author states, with reference to this list, that the only tubes which have stood up on service without showing signs of corrosion at all up to the present are Nos. 4, 10, and 12, but that care must be exercised in speaking of trials of such tubes, as there are cases known of Admiralty brass tubes being in service for twelve years and showing no sign of deterioration, and, with the exception of No. 11, none of the tubes have been fitted in ships for longer than five years. He also states that No. 6 has only just completed one year's trial and the coating has been found to be removed in places, and No. 4 has not been long enough in use or in sufficiently varying types of ships to assume that it will give good service under all conditions.

Alloys for Turbine Blading.

The blading problem in high-pressure turbines is one on which much work has been done and one which has never been satisfactorily solved. To obtain material which will withstand without deteriorating the eroding effect of high velocity superheated steam has been a constant source of trouble, and has led to many investigations. For the high peripheral speeds now prevalent in modern turbine practice, such alloys as phosphor bronze (copper 97%, tin 3%, phosphorus 0·1%), and manganese copper (copper 96–97%, manganese 3–4%) are no longer satisfactory, and are not used to the same extent as they were. Alloys of copper and nickel, particularly Monel metal, have been found to be suited to such conditions, and have been used in some

cases in preference to ferrous alloys. In the *King George V.*, where high pressures and high temperatures prevail—550 lb. per sq. in., and 750° Fahr.—this material was used for the turbine blading and shrouding in (*a*) the high-pressure-ahead turbine; (*b*) the first and second intermediate pressure turbines on both sides; and (*c*) the impulse turbine. According to Hope-Harrison[3], Monel metal turbine blading is also used by the Admiralty in the h.p. and astern stages of turbines.

TABLE I.

1. Stainless steel.
2. Staybrite steel.
3. Monel metal.
4. Aluminium bronze.
5. Melloid.
6. Chromium-coated brass.
7. Corronil.
8. Synthetic Monel.
9. Copper nickel 80 : 20.
10. Copper nickel 70 : 30.
11. Admiralty brass.
12. Silveroid.

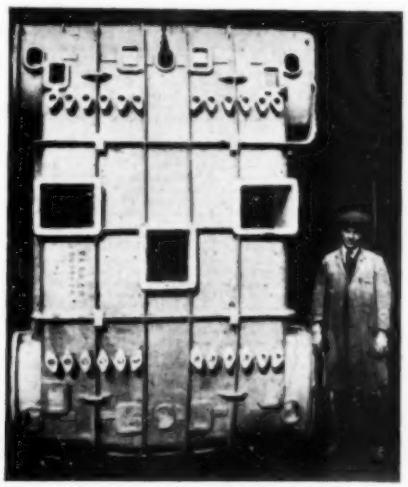
A special non-ferrous alloy which is used to a limited extent in turbine work as a solder is a silver alloy containing approximately 43% silver, 37% copper, and 20% zinc.

Alloys for Steam, Turbine, and Oil Engines.

Monel metal and high nickel-copper alloys are also used for the manufacture of valves, valve seats, and spindles, both in high-pressure boilers and for parts of the steam-line where superheated steam is used in marine engines on account of their resistance to erosion and corrosion. These alloys are also used for pump spindles, impellers, and drain cocks, and for the manufacture of studs and nuts on superheaters, or turbine nozzle plates, parts which suffer deterioration rapidly when exposed to high steam temperatures.

Supports for superheater tubes which are exposed to stresses over 1,000° F. have, according to Hope-Harrison[3] been constructed of such special non-ferrous alloys as "Cronite," an alloy containing 68% of nickel, 15% of chromium, and 1·0% of manganese; and "Brightray," an 80% nickel, 20% copper alloy.

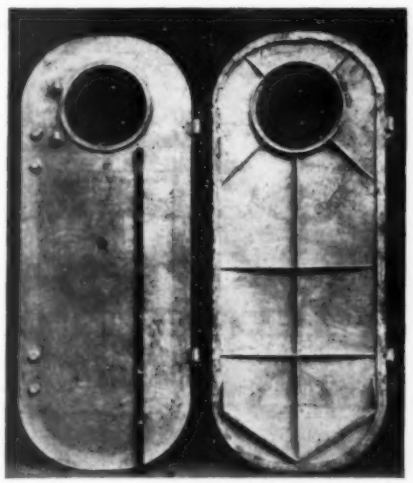
Among the problems which the development of the internal-combustion engine have brought to marine engineers is the question of materials which will withstand stresses at high temperatures without oxidation and scaling. This problem has been met to a large extent by the use of special or alloy steels containing high percentages of such non-ferrous elements as chromium, nickel, tungsten, and molybdenum, but most of these are reckoned as ferrous alloys. When, however, the percentages of non-ferrous metals exceed those of the iron, the materials may be reckoned as non-ferrous, and of late some very useful alloys of this type have been developed, and their application in marine engineering is only a question of time.



(*By courtesy of Light Alloys Ltd.*)

Main cover for Turbine Gearcase in aluminium silicon alloy. One of the largest aluminium castings ever made in this country.

The properties of one such alloy developed by the National Physical Laboratory is described by Archbutt[4] in a recent paper. It consists of nickel, chromium, iron, tungsten, and silicon, and has a tensile strength of 30 tons per sq. in. at 800° C., and withstands a load of 5 tons per sq. in. for 68 days without fracture. This author also states that further work on these alloys is in progress and an apparatus has been designed for carrying out creep tests in a vacuum of less than 2/1,000 mm. at 1,000° C.



(*By courtesy of Light Alloys Ltd.*)

Inspection doors in aluminium-silicon alloy for Diesel engines.

Turning again to the question of protection of materials from corrosion and erosion, methods which have been evolved employing non-ferrous metals are those of spraying and electro-deposition, and both methods have been used in marine engineering and shipbuilding to a limited extent. Iron and steel surfaces are protected from corrosion by non-ferrous metals, such as aluminium, chromium, nickel, cadmium, etc., sprayed from a pistol.

Aluminium, when sprayed over iron and steel, flows into the iron, and when the iron is heated the iron and the aluminium diffuse and form an alloy coating to the depth of one-fortieth of an inch. Such a coating withstands temperatures up to 900° to 1,000° C. without scaling, and such parts as boiler superheaters exposed on both sides to hot gases, baffles, and superheater fasteners, have been very successfully treated. On the *Europa* and *Bremen* it is stated that over 80,000 sq. ft. of boiler material have been protected by being sprayed with aluminium. Boiler tubes in large marine boilers have also been treated by this method against the action of boiler gases, such tubes being found to be satisfactory after three years' service, whereas uncovered tubes failed after four months under similar conditions. Such tubes, however, cannot be worked cold, as the protective coating will not resist bending, and curved tubes have to be sprayed in position.

The electro-chemical deposition of non-ferrous metals on to iron and steel surfaces is also used successfully, not only to obtain a protective coating, but also to build up worn parts. The Fescol process, where a metal is deposited electrically into the structure of the original metal, ensuring a joint which in many ways resembles a soldered joint, and which also forms a protective layer, has, according to Hope-Harrison,[3] been used by the Admiralty in naval engineering for coating such parts as :—

1. Condenser tubes.
2. Working parts of steampipes in expansion glands.
3. Steam valves subjected to superheated steam.
4. Damaged rotor shafts.
5. Damaged turbine wheels.
6. Surfaces working through glands in contact with water.

As will be seen, this process can be useful in three ways. First, it can either protect steel or light alloys with a layer of an exceedingly hard and uniform metal. Secondly, it provides a finished surface for wearing parts harder and more resistant to corrosion and erosion than the original material, and finally, it is possible to renew worn or damaged parts instead of replacing them. Nickel and chromium are the metals most generally deposited, and

both have given satisfactory results in service. Regarding the strength of such deposits, it is stated that tests carried out by the National Physical Laboratory have shown that the resistance to shear of a thick ring of nickel deposited round a steel shaft is practically that of the metal itself, so close is the adhesion. It is also pointed out that it is not desirable to arrange for two parts on which nickel has been deposited to engage with each other, as, for instance, a valve-guide and a valve-pintle.

Another special alloy which has recently been put forward as a substitute for Admiralty gunmetal, and which is being used to a limited extent in-marine work, is the alloy known as P.M.G. This is a copper silicon alloy containing 3 to 4% silicon. In its cast condition it has a tensile strength of from 18 to 22 tons per sq. in., and in its forged, rolled, drawn, and extruded condition a strength of 33 tons. If tests made with it prove successful under service conditions, it should find application for many parts where gunmetal, manganese, bronze, and other special bronzes are now used on account of the saving in weight due to its superior properties.

Aluminium Alloys.

Until recently light alloys of aluminium were seldom used in marine engineering, although they had many properties in addition to their lightness in weight to recommend them. The principal objection to their use was their corrodibility by sea water, but this objection has been overcome by the discovery of new alloys and of methods of "anodic" protection, with the results that many tons of such alloys are now used in the construction

(By courtesy of Monel-Weir, Ltd.)

Table tops, sinks, and drainboards of Monel Metal in the galley of s.s. "Prince Robert."

of a battleship, cruiser, or destroyer, and to a lesser extent in general mercantile work, and have led to a considerable saving in weight. Improved methods of manufacture, resulting in gas removal and grain refining, have also improved the general properties of these light alloys.

The principal alloys of this class used in shipbuilding and marine engineering are the Y alloy, the aluminium-silicon alloys (10 to 13% silicon), and the aluminium-copper alloys (8 to 10% copper). The Y alloy developed by the National Physical Laboratory contains 4% copper, 2% nickel, and 1·5% magnesium. By improved methods of heat-treatment and "ageing" a tensile strength of 18 tons per sq. in. is attained, and it retains its strength well as the temperature increases. It also resists corrosion by sea water, and is capable of anodic treatment. The aluminium silicon alloys developed during recent years give extremely good castings, and if properly "modified," a tensile strength of from 9 to 14 tons per sq. in., with an elongation of 5 to 10% on 2 in., according to their condition of manufacture. Their resistance to corrosion by sea water is high, being better than most aluminium alloys. Aluminium-copper alloys, formerly used to a limited extent in marine work, are now almost entirely replaced by the silicon alloys, owing to their greater liability to sea-water corrosion.

As regards the use of these alloys, the Y alloy has been used for both naval and mercantile Diesel engine pistons. Apart from the reduction in weight which is secured by the use of this alloy, there are also other important properties which it possesses, rendering it particularly suitable for such parts. The thermal conductivity is much higher than cast iron—0·35 as against 0·125. Inertia forces are reduced on account of the reduction in reciprocating weight, which is an important factor when dealing with high-speed engine inertia forces and bearing pressures. These properties allow of pistons of larger diameter being used before piston cooling has to be used.

The aluminium-silicon alloys, on account of their good casting properties, are used for a variety of purposes, both in engine and hull construction, and their use is extending. In marine engines, such parts as valves and filters in fuel and lubricating-oil systems, pump bodies, gear cases, pipe-line junctions, brackets, and doors, are now constructed of this alloy; while on board ship they have been introduced for such parts as skylight frames, side-lights, stanchions, hand-wheels, small fittings, brackets, pedestals, and searchlight bodies; such parts are exposed to sea water or to an atmosphere impregnated with salt, and they resist corrosion well.

Alloys for General Use.

In shipbuilding non-ferrous metals and alloys are taking the place of iron and steel, and also of wood for many parts in the internal construction of a ship. In parts where food is being handled, such as pantries, galleys, and kitchens, opinion is gradually developing that the use of wood is insanitary, and that more cleanliness and satisfaction is obtained by the use of certain non-ferrous materials, with the result that more and more of these materials are being used by shipping firms.

Two alloys which have been used are Monel metal and the nickel-copper alloy known as Silveroid. Both alloys, due to their high nickel content, have a silvery white appearance, a high resistance to atmospheric corrosion, and are very easily cleaned, which is an important quality, especially when dealing with food. The former has been used for the covering of mess and galley tables, bar counters, hot tables, cooking pans, etc., and the latter for such parts as table-top linings, sinks, chests, hot presses, and cooking utensils.

Similar alloys of copper and nickel have also replaced brass for many cabin furnishings. Bathroom fittings, rails, rods, rings, hooks, door handles, door fittings, lamps, and electric light fittings are only a few of the various articles so replaced. A large number of similar fittings and parts have also been chromium plated, and the use of this process is continually being extended, not only on account of the stainless properties conferred, but articles so treated have a good appearance and wear extremely well.

Pure metals have also been used for covering the walls or sides of pantries, kitchen, and galleys, instead of painting. Aluminium, nickel, chromium, and zinc are sprayed on by some form of pistol or sprayer, and form a thin coating of metal which is said to give very satisfactory results.

For the sheathing of cables lead is largely used, but owing to vibration cracks develop in the lead, commencing inside the sheath. Investigations carried out by the British Non-Ferrous Metals Association have led to the introduction of a new alloy for this purpose which consists of lead with a small quantity of cadmium, and either tin or antimony. This alloy is said to have a high tensile strength, a better fatigue value, and a lower specific gravity than lead, and is specified by for cable sheathing.

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Stabilising Economic Conditions.

THE artificial extension of a considerable section of the manufacturing plant which has been erected or reconstructed since 1914 is largely responsible for the abnormal capacity for production among the peoples of the world. This rapid installation of new plant was really due to an exceptional demand which, unfortunately, manufacturers too optimistically believed to be normal. Although conditions fluctuated following the cessation of hostilities, producing a crisis in 1921, a cycle of prosperity begun in 1923, and coinciding with further developments in industrial plant, led to an activity almost unparalleled in industrial history; efforts to supply the world with a wide variety of manufactured goods and appliances caused a burst of productivity which appeared likely to prove permanent and indefinitely increasing. It was inevitable, nevertheless, that the time would come when the demand for these manufactured goods would dwindle and plainly show itself to be incapable of keeping pace with a supply altogether beyond its needs. The effect was felt about 1927; until then few people had regarded its possibilities as a future menace.

A further reminder that "Metallurgia" now occupies more commodious and central offices, and all correspondence should be addressed to 21, *Albion Street, Gaythorn, Manchester.*

After much uncertainty and delay the limitation in the production of manufactured articles is now being imposed necessarily, and in all directions. Difficult operations of readjustment and reorganisation have been involved, which included the liquidation of post-war surplus and the closing down of those works incapable of healthy survival, while consolidating those which have shown real vitality. It is only recently that the beneficial effects of liquidation are beginning to be felt, chiefly in the form of an all-round reduction.

During this time nations have been suffering from the incubus of war debts and reparations, which, many far-seeing people realised long ago are indisputably linked up with industry. The recent gesture by President Hoover on behalf of the American people is another indication of the general realisation that the burden of war payments, together with their questionable adjustments, do not affect financial considerations only, but the economic and, eventually, industrial developments.

The initiative displayed by President Hoover has definitely opened a way to a new and thorough consideration of the whole international debt and reparations problems within a comparatively short time. It is true that, at the time of writing, the conciliatory spirit incorporated in the holiday policy is in jeopardy, but, while the spirit of the gesture will lose much of its value through lack of spontaneity in its acceptance in principle, it is unthinkable that the effort will be frustrated in its entirety.

The British Ministers are certainly to be congratulated on their rapidity in putting the Hoover holiday into immediate operation as far as it concerns the British Empire, and Germany is unconditionally relieved from payments falling due on July 15. France, on the other hand, apparently wants to impose conditions before agreeing to the proposed policy. These demands refer to the postponement of the Austro-German Customs Union scheme and the suspension of the construction of the second "pocket battleship," during the period of the proposed holiday.

We are inclined to think that these demands are being raised for some other reason, as the question of the Austro-German Customs Union is to be discussed at the Hague Court, when a pronouncement will be made regarding its legality, and the question of the battleship could well be reserved for the Disarmament Conference, which is due to open at Geneva about six months hence. It seems more likely that France realises the effect this debt and reparations holiday will have on future settlements. Obviously, if the world experiences an economic revival during the period of the Hoover Plan, it will naturally be concluded to have provided a remedy. It will be generally agreed that, if a year's postponement of debt payments improves the economic structure and benefits world trade, no economist will desire to interfere with business by resuming payments on the previous scale. On the other hand, with little or no improvement in trade resulting, there will be a reasonable demand for the immediate and drastic liquidation of the war through reduction or cancellation of debts. France undoubtedly envisages the modification of the Young Plan, and in this respect she is right, for there is small prospect of it being applied in its entirety again, and as chief recipient of reparation payments, she has naturally a deep concern about her financial future.

Although the beneficial effects of the liquidation of the post-war surplus are beginning to be felt, improvement is slow, and the low prices that have been forced on manufacturers is a contributory cause, but France has, and, indeed, all European nations have, a wonderful opportunity of restoring the economic situation engendered by the financial collapse of Germany—France, in particular, because she is the only European nation with the financial resources to meet the difficulty, and because she can foster that spirit of goodwill so ably initiated by President Hoover. Undoubtedly, the liquidation of war debts and reparations would give an impetus to the rapid restoration of credit and would pave the way to a better conception of peace and its effect on the world's economic structure.

While the causes of Germany's crisis are not wholly due to the war debt and reparations problem, the fact remains that her present state is a menace to the peace and prosperity of the world, and anything done to bring relief will immediately have an effect on credit and tend to remove the present note of despondency in industry.

It must be borne in mind that increased consumption, upon which manufacturing countries must rely, is dependent upon restoration of the peace and goodwill which fosters human evolution, and, so long as the peace of the world is undisturbed and goodwill predominates, the process of industrial readaptation will proceed slowly, and, given the right conditions, will re-establish itself, and the demand for manufactured articles will increase and regain the level to which it had previously been artificially raised.

The Macmillan Report.

THE Report of the Committee on Finance and Industry, which has been sitting since November, 1929, under the chairmanship of Lord Macmillan, has just been published. It is a document of over 300 pages, and is very comprehensive in its scope. It is divided into two parts, the first being of a historical and descriptive nature, while the second gives the Committee's conclusions and recommendations, together with a memorandum by Lord Bradbury, explaining his reasons for disagreeing with most of the conclusions of his colleagues.

The first part of the report conveys a very instructive idea of the operation of the international gold standard, and, as might be expected, emphasises the working of the London money market under the exceptional conditions that have prevailed since the war. It is apparent from this review that the gold standard no longer operates as automatically as it did before the war; it is influenced more by various factors which have since been associated with the economic life. It seems that the present world depression, resulting in a fall in prices almost unparalleled, is not directly due to the gold standard, although the view is held by some members of the Committee that our return to the gold standard in 1925 was a mistake, and did not result in the advantages anticipated by those who were responsible. This does not mean, of course, that the consequences can be remedied by a reversal of the policy to-day.

Considerable stress has been laid on the consequences of the heavy fall in world prices since the Committee commenced their deliberations, which, in view of the German catastrophe, has an important significance. In their view, stabilisation of prices is of primary importance, and this should be the duty of central banks, otherwise, the international standard will collapse. Certainly at the present time there is much need of a concerted international effort to restore prices to a remunerative level, and then to stabilise them.

The Committee stress the need for closer international co-operation to effect what banks of issue were accustomed to do independently before the war; they have, in fact, assumed that the next phase in monetary policy will consist in making the existing international standard work more satisfactorily as a result of greater harmony in giving effect to its operation.

In regard to the financing of industry, the Committee are satisfied that the banking system is satisfactory in the provision of the normal short credits to industry, but they suggest that all concerned would benefit by a more extended use of the commercial bill as part of the mechanism of home business. They appreciate the need for closer co-operation of finance and industry, and suggest a development of financial organisation to advise industrial companies and carry out various forms of financing business. The big banks and the leading private banking institutions could well co-operate in setting up such institutions. The methods of issuing foreign securities in this country and home industrial securities are contrasted, and the Report points out that of all central institutions the Bank of England is most often torn by these divergent interests.

The Committee attribute the heavy fall in prices to the maldistribution of gold, which has led to the instability of post-war international finance. The main causes being the burden of War Debts; the dispersion of initiative caused by the entry of the United States into the group of chief creditor countries; the non-productive character of many post-war loans; the preference for liquid assets, as compared with long-term securities; and the movements of gold ceasing to have the normal effect on domestic credit policies.

Lord Macmillan is to be congratulated on the tact displayed in dealing with matters over which much active political controversy prevails, and on which general agreement among the members of the Committee could hardly be expected. The Report is valuable in that it allays the distrust with which high finance has been increasingly regarded by the business community.

Progress in the Use of Metals at Elevated Temperatures.

IT is now generally appreciated that the increasing high steam pressure employed in power-plant installations has given rise to a large number of problems which depend for their solution on a complete knowledge of the properties of materials at high temperatures. In addition to power-plant work, there are a number of industries, notably the chemical industry, oil industry, roasting, refining and smelting industries, ceramic industry, etc., in which metals are used under high-temperature conditions, and in the interests of both safety and economy continuous research is being vigorously carried out in order to determine correct methods of design and the most suitable materials of construction. In these rapidly expanding fields of activity much progress is made each year, and it is useful at intervals to determine the extent of the knowledge obtained on the subject.

An effective way of achieving this object is by free interchange of information or ideas relating to the effect of temperature on the properties of metals in all its phases. This necessitates joint effort, together with the successful direction and co-ordination of activities by some agency familiar with the field and its workers.

The co-ordination of the information on ideas relating to this subject is one of the primary functions of the American Joint Research Committee on the Effect of Temperature on the Properties of Metals, and, to further its objects, the Committee arranged for a symposium at a joint meeting of the American Society of Mechanical Engineers and the American Society of Testing Materials, which was held at Chicago recently. The symposium was arranged for two sessions, but as more data was accumulated than could be presented, even in abstract, at the sessions allocated to the Societies, a novel method of handling it was adopted. The subject was considered in two important phases: (1) The present and probable future demands of important industries for materials for service at high and low temperatures; (2) the present state of knowledge of the properties of available metals and alloys and their industrial application.

Instead of the presentation of the individual papers by their respective authors, they were divided into two groups, corresponding with the two phases upon which the discussion was based, and a general review of each was given by a qualified member of the Joint Committee. The adoption of this method permitted a broad view to be taken of the entire data, and gave the maximum time for discussion, which is so important at meetings of this character.

Primarily this symposium was arranged to show what the various industries require and what the manufacturer may be able to produce; it should, however, tend to develop the limits of the metals at present available to industry, and, in this way, serve to indicate profitable fields for research, in which metallurgists can perhaps provide metals of even greater usefulness.

FORTHCOMING MEETINGS.

INSTITUTION OF MECHANICAL ENGINEERS.

July 13-17, Annual Summer Meeting at Cambridge.

Readers are reminded of the interesting meetings arranged for September. The first International Congress of the New International Association for the Testing of Materials will be held at Zürich, Switzerland, from September 6 to 12, in the buildings of the Swiss Federal Polytechnicum. Closely following this Congress is the Annual Autumn Meeting of the Institute of Metals, which also will be held in Zürich. This meeting, which is announced for September 13-15, is being held by invitation of the Schweizerische Verbaud für Materialprüfung. Following this meeting at Zürich, optional tours will be made to Lucerne, Thun, Biel (Bienne), and Chippio-Siders (Sierre) from September 16 to 18. In addition an International Foundry Exhibition and Congress is to be held at Milan, Italy, from September 12 to 27. This Congress concludes on September 16 but the Exhibition remains open until September 27.

The Newly-discovered Element, Hafnium.

HAFNIUM, one of the most abundant of the newly discovered elements, has not yet found a definite place for itself in industry, according to the United States Bureau of Mines, Department of Commerce. A commercial future for hafnium is, however, already glimpsed in the radio industry, and its high melting point and electronic emissivity have already led to the taking out of patents for its use in radio tubes and incandescent electric lamp filaments and for the cathode surfaces of devices such as X-ray tubes and rectifiers.

Hafnium, which is element number 72, takes its name from Hafniae, the Latin name for Copenhagen, Denmark, where the research work of Coster and Hevesy, discoverers of the element, was performed, says Paul M. Tyler, in a report recently published by the Bureau of Mines. Hafnium has so far been found only as a minor constituent of zirconium minerals.

Due to the fact that the separation of hafnium compounds from zirconium compounds is laborious, and because of the lack of any extensive demand, hafnium compounds are expensive and not particularly easy to obtain in the market. In the United States practically none of the metal seems to be available, but hafnia (the oxide) and hafnium chloride can be purchased in small quantities at a price of approximately $25 a gramme. Ores containing up to about 3% of hafnia can be bought for about 50 cents a pound, and ore containing 5·5% may be had for $1·50 a pound.

The richest hafnium ores are the altered zircons, especially cyrtolite. The unaltered zircons, the native oxide (baddeleyite) and eudialyte, being more abundant, are the more important of the leaner hafnium ores.

Unaltered zircon, the only commercial hafnium ore in the United States, which usually contains less than 2% of hafnium oxide, has been mined intermittently in Henderson County, N.C., and at Pablo Beach, Florida, and has been reported in Virginia, near Ashland. It also has been found near Indiahoma, Commanche County, Oklahoma. Baddeleyite has been reported in Montana, and eudialyte has been found in Arkansas.

Of the ores richest in hafnia, the altered zircon, cyrtolite, which is the most widely distributed, occurs in at least eight States, as follows: California, Colorado, Connecticut, Massachusetts, New York, North Carolina, Pennsylvania, and Texas. It is also found in India, Madagascar, Italy, Sweden, and Canada. Alvite, which does not seem to be common, but which was useful to early investigators of hafnium, occurs in Norway. Of the ores lean in hafnia, the zircon of commerce has come from the monazite sands of Travancore, India, and of Brazil, and from the pegmatites of Southern Norway. Baddeleyite, the native oxide of zirconium, occurs in Ceylon, Italy, Sweden, and especially in Brazil, in the States of Minas Geraes and Sao Paulo. Boulders in the Brazilian deposit have been found that weighed as much as 30 tons; such boulders would probably contain 300 lb. to 400 lb. of hafnium oxide.

The complex eudialyte, said to be a third hafnium mineral of great interest, is reported to be very abundant in Hibina-Toundra and Lajavr-urt, in the Kola Peninsula of Russian Lapland. Eudialyte is reported to be of common occurrence in the alkaline syenites in Greenland, about the fiords of Tunugdliarfik and Kangerdluarsuk, in the Julianehaab district.

The first hafnium salts produced in the United States were made by the late Prof. C. James, of the University of New Hampshire in 1924 from cyrtolite from near Bedford, N.Y. However, although the zirconium salt which he prepared concomitantly appears to have been free from hafnium, the hafnium salt was unfortunately contaminated in process by zirconium through the interchange of fractions by careless workmen who had access to the laboratory. To date, therefore, pure hafnium salts have apparently not been prepared in the Western Hemisphere. Apparently the metal likewise has not been produced in the United States, but a small sample of the first metallic hafnium ever made was presented by G. Hevesy for permanent exhibition in the element collection being made by Dr. George F. Kunz at the American Museum of Natural History in New York City.

Practically all the hafnium and its compounds that have been isolated so far have been consumed in scientific and experimental work, and production has been confined to a small laboratory scale. In 1930, however, de Boer and Fast are said to have prepared some 70 grammes of 100% hafnium oxide from which they made some pure, ductile metal, as well as a series of hafnium-zirconium alloys.

VICKERS WORKS, SHEFFIELD, ENGLAND
"SHEFFIELD STEEL FOR CANADIAN PRODUCE"
MADE BY THE ENGLISH STEEL CORPORATION Ltd
VICKERS WORKS, SHEFFIELD, (ENGLAND)
"SHEFFIELD STEEL FOR CANADIAN PRODUCE"

High-tensile alloy steel drums for use in chemical works in Canada. The two larger forgings weigh 42 tons each, while the smaller weighs 23 tons. Made at the Vickers Works of the English Steel Corporation, Limited. It is of interest to note the posters of the Empire Marketing Board, which are displayed with the object of helping Imperial Trade.

Electrical Order for Manchester.

An electrical order to the value of approximately £104,000 has been secured by Metropolitan-Vickers Ltd., of Manchester. This order, which has been placed by the Victoria Falls Power Company of South Africa, is for a 26,000 kilowatt turbo-alternator condenser set. The work has to be put in hand almost immediately.

Aluminium Sheet Production

By Robert J. Anderson, D.Sc.

Part VIII.—Pre-treatment of Rolling Ingots.

In this article the author deals with methods of pre-treating aluminium and aluminium-alloy ingots before hot rolling; pre-heating furnaces; scalping and dressing of ingots and slabs, as well as equipment for these operations; and methods and equipment for delivering ingots to the hot mill, either directly from the moulds or from pre-heating furnaces.

IN aluminium hot-mill practice, ingots are broken down to slabs by rolling either directly from the moulds, after cooling sufficiently, or after pre-heating in a furnace to a suitable temperature. Aluminium ingots are not to be broken down cold—*i.e.*, at room temperature. Ingots of 2 S and some alloys may be rolled directly from the moulds, being first cooled to the required temperature, and satisfactory commercial sheet may be obtained therefrom. Ingots of duralumin and related heat-treatable alloys are normally first pre-heated before being sent to the hot mill.

Whether ingots are rolled directly from the moulds or first pre-heated, it is advisable to provide for straight-line production in the mill lay-out. This avoids the necessity for complicated conveying systems and extra haulage. In the preferred lay-out, the melting-room is situated behind the hot mill—*i.e.*, at the rear of the roller's side of the mill. So situated, a straight-line conveyer may be arranged between the moulds and the mill, so that the hot ingots may be delivered at one side of the front bed, ready for rolling. Pre-heating furnaces should be situated in straight-line lay-out between the melting-room and the hot mill, so that the distance traversed by the ingots from moulds to mill will be minimum.

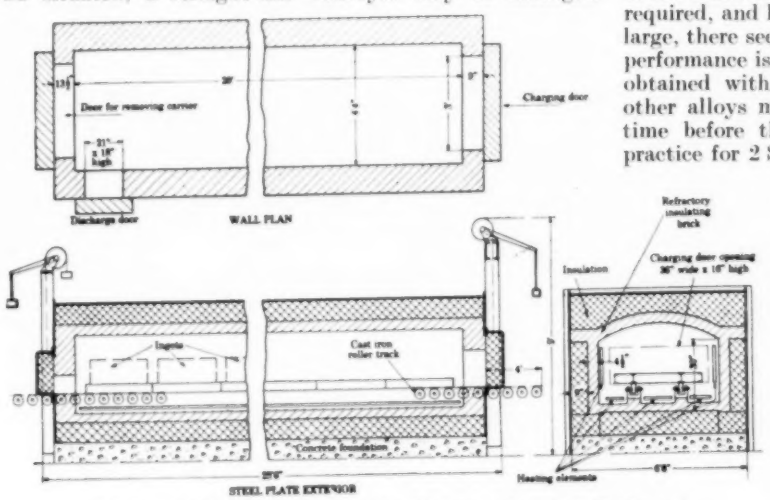


Fig. 1.—Design of Ingot Pre-heating Furnace (After Gas Equipment Engineering Corp.)

As is obvious, the primary object of rolling directly from the moulds is to save money—by utilising the residual heat of the ingots and avoiding the expense of pre-heating. This is the chief advantage, but there are certain definite disadvantages in the practice. One undesirable feature is the lack of temperature uniformity throughout the mass of the ingot. When an ingot is removed from a vertical, tilting book mould, the head end is hotter than the bottom, and the interior is hotter than the surface faces. Another undesirable feature, particularly in tonnage mills, is the necessity for accurately synchronising the rate of production at the mould line-up with the rate of rolling at the hot mill. Otherwise, time will be lost at the mill waiting for ingots, or an excess number will be poured, requiring stacking and subsequent pre-heating. Ingot-production and hot-rolling rates can be adjusted very nicely when the hot mill is breaking down a tonnage order of fast-running material like coil, requiring several hours to a day or more for completion. In rolling slabs for wide sheet, the hot mill consumes fewer ingots per unit of time than in the case of coil. When the breakdown orders are very variable, with numerous odd lots and small parcels of different sizes being rolled, satisfactory synchronization in rolling directly from the moulds is very bothersome. It goes without saying that any failure at the hot mill—*e.g.*, a broken coupling or roll,—interrupts production at the mould line-up, and *vice versa*, in rolling directly from the moulds.

Whether ingots are to be rolled directly from the moulds or first pre-heated is to be determined by the composition of the material, behaviour at the hot mill, quality of sheet required, and local conditions and circumstances. By and large, there seems to be little doubt that more satisfactory performance is had in hot rolling, and better quality sheet obtained with pre-heated ingots. Duralumin and some other alloys must first be pre-heated for long periods of time before the breakdown operation. A compromise practice for 2 S and some alloys, which saves most of the residual heat of the ingots without the disadvantages of rolling directly, calls for charging the hot ingots from the moulds into an equalisation or soaking furnace. The furnace is held at the desired hot-rolling temperature, and soaking for a short time yields ingots of uniform temperature.

Ingots of 2 S and some alloys do not ordinarily require scalping before hot rolling. Ingots of duralumin and some other hard alloys may be scalped before hot rolling, or given a few passes and then scalped in the partly broken-down slab. Material which tends to crack badly on hot rolling may be dressed and chipped between passes.

Pre-heating Rolling Ingots.

When ingots are to be pre-heated for hot rolling, they are stacked in piles on removal from the moulds, and are ordinarily allowed to cool to room temperature before being sent to the pre-heating furnace. However, ingots may be removed from the moulds and charged while hot into an equalisation furnace, any overage being stacked. Ingots which require scalping are allowed to cool before being sent to the overhauling machine. Where the chemical composition must be held within close limits, it may be necessary to defer processing until the analytical results on samples are available and the composition has been approved by the laboratory. In some small plants rolling ingots are purchased from outside sources, and, of course, require pre-heating. In order to avoid repeated handling, ingots to be pre-heated may be conveniently stacked on steel skid platforms, the loaded skids being subsequently

moved to the furnace, as required, by electric lift truck. The details of pre-heating—*i.e.*, time and temperature, depend upon the composition of the material to be rolled, design of furnace, hot-rolling temperatures, method of loading, size of ingots (particularly the thickness), and other factors.

In dealing with 2 S and some alloys, the object of the pre-heating is merely to raise the temperature of the ingot to that required for hot rolling. It is, of course, understood that the temperature of the ingot is to be uniform throughout. In handling duralumin and some other alloys, the object of the pre-heating is two-fold—viz., first, to raise

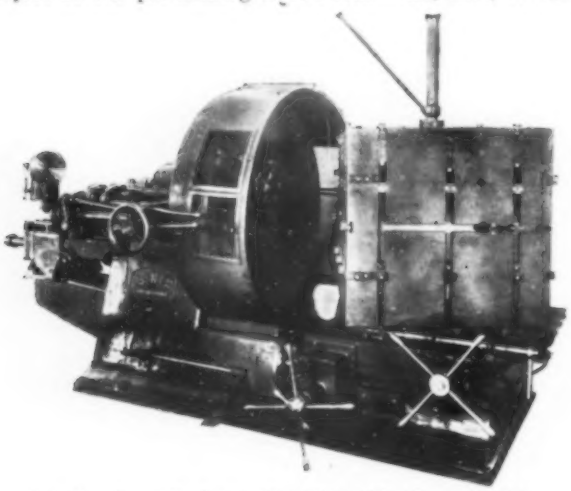


Fig. 2.—Jones Scalper; Operating Side (Jones Machine Tool Works, Inc.).

the temperature, and, second, to effect favourable alteration of the ingot structure. Advantageous change in the microstructure results from the solution of hard constituents—*e.g.*, $CuAl_2$, at an elevated temperature. A solid-solution structure (in a given alloy) is less prone to crack and fissure under rolling pressures than a structure containing a more or less continuous network, or needles, of hard constituents. Heating at an elevated temperature also induces the diffusion of constituents, thereby promoting equilibrium conditions and more or less obliterating coring, inverse segregation, and other undesirable features of the as-cast structure. Practical experience has shown that 3 S-alloy sheet (1·25% manganese) develops large grain size on anneal when rolled directly from the moulds. Accordingly, 3 S stock which is to be used for drawing should be rolled from pre-heated ingots. Duralumin, and related alloy, sheet is normally rolled from pre-heated ingots.

Ingots of aluminium and its alloys are broken down at about 450° C., but higher and lower temperatures are employed in different works, and the temperature is usually varied to suit the composition and other conditions.

In pre-heating aluminium and alloys which do not require soaking to change the structure, the ingots are heated to a temperature somewhat above the preferred rolling temperature—say, 10° to 25° C., so as to allow for heat loss between the furnace and the mill. The time period of heating may vary from 4 to 12 hours, depending on the size of ingot and other factors. Of course the time required for equalising the temperature of hot ingots (charged into a furnace directly from the moulds) is much less than that required in raising cold ingots to the rolling temperature. Thus, in one plant, 2 S ingots, charged hot for equalising, are held in the furnace about 1½ hours; ingots of the same size, charged cold, are held in the furnace for about 6 hours, the furnace temperature in both cases being 475° C.

When duralumin and other heat-treatable alloys are pre-heated, the best results in promoting favourable change in the microstructure are had by heating at as high a temperature as possible, short of actual "burning"—*i.e.*, melting of the eutectiferous matter. Incidentally, the time period required is less the higher the temperature. In practice, the standard quenching temperatures used in the heat-treatment of manufactures made from the various alloys are often employed as the pre-heating temperatures. Thus, in one plant duralumin ingots are charged cold into a furnace held at 515° C., and after attaining this temperature the ingots are allowed to soak for 8 to 12 hours, the time varying with the thickness; this refers to ordinary sheet ingots, weighing 90 lb. to 150 lb. The ingots are cooled to about 450° C. for hot rolling, the alloy being too hot-short at 515° C.

Ingot-heating Furnaces.

Ingot-heating furnaces vary greatly in design and method of operation. They may be fired by gas or oil, or heated with electric resistance units. Gas-fired furnaces appear to be used most generally, but electric heating presents several advantages, notably accuracy of temperature control. Continuous or semi-continuous furnaces are favoured in preference to the batch type. The semi-continuous furnace (or intermittent working of the continuous furnace) is best adapted for feeding ingots to the hot mill because of the tendency toward irregularities in the breakdown operation. Good mechanism for the continuous conveying of ingots in pre-heating furnaces is generally expensive. Most continuous-conveying systems, expensive or inexpensive, are more or less prone to get out of order or wear out rather quickly. The pusher-type feed, in semi-continuous furnaces, is good, the first cost of installation is substantially less than that of continuous conveyers, and the maintenance cost is negligible. Temperature control of ingot-heating furnaces should preferably be of the automatic type. Brief descriptions of typical ingot-heating furnaces are given in the following paragraphs:—

At one plant duralumin ingots are pre-heated and soaked in a gas-fired furnace of the continuous carrier type. The furnace is of the semi-muffle design, and the arch is split or slotted from end to end along the longitudinal centre line. A suspension track is situated above the roof in line with the slot, this track branching at the ends of the furnace and running along both sides—in the form of a flattened, exaggerated figure 8. The special carriers for holding the ingots are suspended from the track, these carriers moving continuously through the furnace toward the discharge end and returning along the sides to the loading end, when the furnace is in operation. Carriers may be designed to hold one or a multiplicity of ingots. The conveying system is motor operated through a speed reducer of the variable type, so that the time period of soaking can be regulated as desired. Ingots are loaded on the carriers at one end of the furnace, pass through the successive heat zones, and are unloaded at the other end. Doors are provided at each end; these are opened and shut by hand, as required for the passage of the carriers in and out. Furnaces of this type have been built in various sizes from 40 ft. to 70 ft. long, and have been used for pre-heating both 2 S and alloy ingots.

Furnaces of the batch type, similar in design to steel forging furnaces, have been used for pre-heating rolling ingots. Such furnaces are poorly adapted to the requirements.

In one plant, a small furnace of the revolving-table type has been employed. Sliding doors are provided on opposite sides of the cylindrical wall for charging and discharging. The ingots are stood up on end on the table, this latter revolving slowly in the heated chamber.

In another plant a semi-continuous furnace of the pusher type has been employed. This furnace is of the semi-muffle type, underfired by natural gas. Inside dimensions are 35 ft. long by 10 ft. wide by 4 ft. high. Double doors hung on pulleys with balance weights are provided at each end. Burner adjustment is manual, and

temperatures are recorded continuously from three pyrometers hung in the roof. Ingots are passed through the furnace by being pushed on a rigid track structure which is fastened to the floor. A track may be made of two ordinary steel railroad rails placed about 1 ft. apart. The present furnace was equipped with five sets of tracks. Ingots are pushed from the charging end towards the discharge end by an ingot pusher; this consists of a ram, having a slow rate of travel, actuated by motor drive. The ram does not travel far—*i.e.*, it cannot push an ingot from one end of the furnace to the other, but it has an effective working movement of about 2 ft.

In order to charge an empty furnace, an ingot is placed on a track at the charging end; the ingot is laid flat across the rails. The ingot pusher is next brought into position, and the ram then shoves the ingot along the track toward the discharge end. The ram is backed off, another ingot is placed in position and pushed forward, and so on, the tracks being filled by pushing forward a number of ingots together. When the tracks are full and the load has been soaked for a sufficient period of time, the ingots are ready for hot rolling. In the operation, ingots are withdrawn from the several tracks in rotation, and as an ingot is removed from the discharge end a cold ingot is loaded at the charging end, the line being pushed forward. In a five-track furnace, which may hold 33 ingots 12 in. wide per track, the operation consists in pushing out, one at a time, and rolling the 33 hot ingots from track No. 1, filling up with cold ingots as rolling proceeds. Ingots are then rolled from track No. 2, then from track No. 3, and so on. By the time the ingots on track No. 5 have been rolled, those on track No. 1 are ready. The working may thus proceed continuously. When a cold furnace is started, it may require 10 to 12 hours to raise the ingots to the rolling temperature. With continuous rolling and loading, each ingot will be in the furnace about 6 hours.

The semi-continuous pusher-type furnace is well adapted to pre-heating either aluminium or alloy ingots. When the time period of soak is long, the operation may be of the batch type, or the capacity of the furnace (size and number of tracks) may be increased, so that the ingots remain in the heat for the required time, and the operation may still proceed continuously. Ingots may be loaded two high in this type furnace. Stationary roller conveyers may be used in lieu of tracks, the ingots being pushed forward together on the rollers.

Fig. 1 shows construction sections of an electrically heated ingot furnace. The design may be adapted for either continuous or semi-continuous feeding. Thus, the roller conveyer may be of the geared motor-driven type, so that the ingots may be moved forward continuously, or the roller conveyer may be of the stationary type, and the ingots may be pushed forward in a line. In the design shown, carrier pans are provided for holding the ingots, these pans riding on the rollers. This furnace was designed for installation in a mill where lack of space prevented set-up at right angles to the hot mill. Accordingly, the furnace was laid out parallel to the mill, and the ingot-discharge door was arranged in one side at the end opposite the charging end. Details of the construction, and changes in design which may be readily made, are evident from the drawing. Power consumption in operating this furnace was calculated as 70 kw. per hour when heating 10,000 lb. of ingots in 24 hours of continuous operation after the furnace has attained the working temperature of 515° C. The standby losses were calculated as 21 kw. per hour. In later articles dealing with the annealing of aluminium sheet, some information will be given regarding the cost of operating ingot-heating and annealing furnaces.

Various other designs of ingot-heating furnaces—*e.g.*, those using wire belts or chains for conveying, might be described, but sufficient has been said to indicate the type of equipment employed.

Scalping.

Scalping is the term applied to the operation of removing a layer of metal from the surfaces of the largest faces of ingots or partly broken slabs. Following brass practice, scalping is also referred to as overhauling and scraping. The object of scalping is to remove surface imperfections and inequalities from the ingot, which would cause trouble in hot rolling or, ultimately, rejection of the sheet. Ingots of duralumin and some other alloys, which are liable to inverse segregation and consequently cracking and fissuring in the hot breakdown operation, are normally scalped. Ingots of aluminium and some alloys are not ordinarily scalped; however, such material may be overhauled when very high-grade, well-nigh perfect finish is required for the sheet. Other things being equal, the smoother the surface of the ingot the less the liability of cracking in rolling, and the better the surface finish of the resultant sheets.

As indicated, material may be scalped in the ingot or in the partly broken-down slab (or both), depending on the alloy, the tendency toward cracking, and the condition of the surfaces. The depth of layer removed is usually about $\frac{1}{8}$ in., but it may be as much as $\frac{1}{4}$ in., depending on the appearance of the surfaces and other factors. At one plant, it has been the practice to scalp duralumin ingots $\frac{1}{8}$ in. deep on the opposed largest surface faces, pre-heat, and then hot roll to the desired slab thickness. At another plant, duralumin ingots measuring $4\frac{3}{4}$ in. by 12 in. by 24 in. are pre-heated and then broken to 3 in. thick with a few passes; the partly reduced slabs are then flattened, scalped $\frac{1}{8}$ in. deep or a little more, re-heated, and rolled to the required thickness. Flattening may be done by passing the slab through a heavy-duty roll leveller. In a German plant, hard alloy ingots are given a few light passes after pre-heating, the partly broken slabs are flattened and then scalped about 0·1 in. deep, followed by further pre-heating and rolling to about 0·3 in. thick. In still another plant, duralumin ingots are scalped, pre-heated, and hot rolled to about half the required slab thickness. The slabs are then cooled and overhauled by dressing with a mechanical chipping chisel. It will be understood that the depth of scalping is governed in large part by the depth of the cracks, in the case of partly broken slabs.

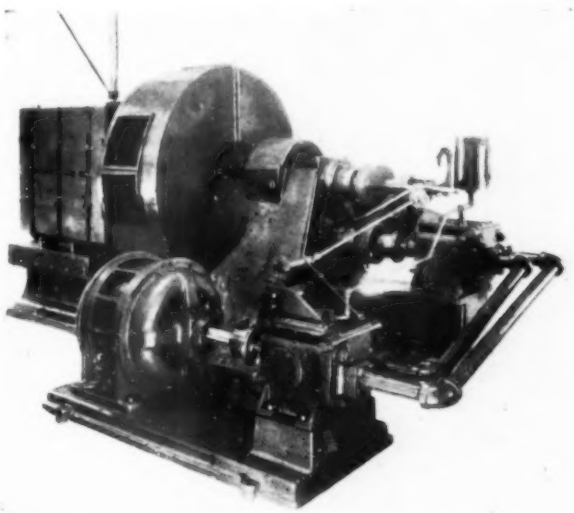


Fig. 3.—Jones' Scalper, Driving Side (Jones Machine Tool Works, Inc.).

Scalped surfaces of aluminium-alloy ingots should be free from scratches, gouges, and tool marks. Also, care should be taken in handling scalped ingots in the furnace, and to the hot mill to avoid unnecessary marring of the surfaces.

Scalping Machines.

Various kinds of machine tools have been used for scalping aluminium-alloy rolling ingots. These include shapers, milling machines, boring mills, lathes, so-called scratchers or scraping machines of the advanced Stever type (such as have been employed generally in overhauling brass slabs), and special rotary machines—*e.g.*, the Jones scalper. Preferably, equipment for aluminium-ingot scalping should be especially designed for the operation. The adaptation of ordinary machine tools has not given satisfactory results. Cutting tools must, of course, be ground with the approved rakes and clearances for aluminium and its alloys.

As is well known, the Stever-type scraping machine consists essentially of a motor-driven reciprocating table to which the work is clamped, and an overhead arm which carries the cutting tool in a rocking holder. The slab is dressed on one side and then turned over and scraped on the other. Operation is similar to that of a shaper, but the table reciprocates at high speed—200 strokes per minute. Rotary scalping machines—*e.g.* the Chatfield type, have been used in brass practice. These are designed to scalp both sides of the slab at the same time. The action is comparable to that of a mechanical wood planer, and the slabs may be passed through the scalping rolls on edge or flat, depending on the design. Brief descriptions of the advanced Stever and the Chatfield rotary machines have been given by Krom.[1]

The Jones scalper was developed recently by the Jones Machine Tool Works, Inc., Philadelphia, especially for aluminium-alloy ingots. This machine has given satisfactory results in American practice. Fig. 2 shows the operating side of the Jones scalper, and Fig. 3 shows the driving side. Ingots are mounted in a vertical position on the four-sided turret head. Eight ingots may be held at one time by clamping two to each side of the turret. The turret is hand indexed, and is equipped with a quickly acting lock and clamp device. Adjustable stops and clamps are provided on all sides to the turret, so that ingots of various sizes can be mounted. In the operation, all four sides of the turret are loaded, and the successive sides are presented in turn to the action of the cutting tool. Ingots are turned over, removed, and loaded during the scalping, so that the machine may be kept in almost continuous operation.

A single cutting tool is employed in the Jones machine, this being fed from the periphery of a cutter head of large diameter toward the centre. In the design of the machine, provision was made for a fast fixed cutting speed at all diameters of the work. Fixed cutting speed is maintained throughout the scalping by the use of a Waterbury oil pump and motor, with gearing which automatically increases the rotating speed of the cutter-head as the tool approaches its centre. In order to permit operating at high speed, the cutter-head is mounted on a spindle of large diameter, equipped with roller bearings. The operating side of the machine with its centralised control, the cutter-head with safety cover, and the indexing turret fixture are shown in Fig. 2. The driving side of the machine with the Waterbury speed-maintenance unit is shown in Fig. 3. Excellent surface finish on ingots is obtained with this equipment.

Handling Ingots to the Hot Mill.

Rolling ingots may be delivered to the hot mill conveniently by roller conveyer or by means of a small-wheeled buggy. The method and arrangement will be governed by the mill layout and the relative positions of the equipment. Delivery of hot ingots either directly from the moulds or from a pre-heating furnace may be accomplished satisfactorily by means of a gravity roller conveyer.

At one plant, in rolling directly from the moulds from a double line-up of the vertical, tilting book type, a roller conveyer is situated between the two lines. An idea of the arrangement may be gained from Fig. 7 of the previous article of this series.[2] The ingots are pulled out of the moulds with suitable tongs, dressed by scratch-brushing the surfaces and chopping off any fins, and laid on the conveyer. At the plant in question the mould line-up is situated at a distance of about 100 ft. from the hot mill, and approximately in line with the mill. Other equipment is interposed. A motor-driven elevator conveyer picks the

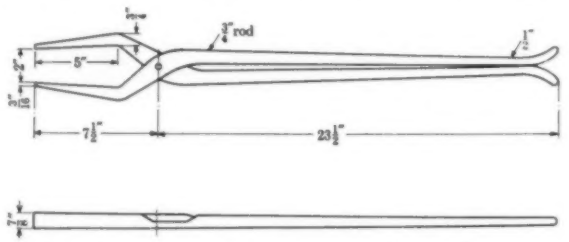


Fig. 4.—Tongs for Handling Ingots from Moulds.

ingots up from the stationary roller conveyer between the mould lines, and raises them to an overhead gravity roller conveyer. The ingots run along this latter conveyer to a position a little beyond the hot mill. Here they descend on a spiral roller slide, which reduces the speed, and are deposited on a stationary roller conveyor at the left-hand side of the mill. The ingots can then be easily pulled over on to the mill bed by the hot roller. Fig. 4 shows a handy form of tongs for removing ingots from vertical, tilting book moulds, and depositing them on a conveyer or stacking on skid platforms.

If the conveyer is situated at some distance from the moulds, or if the ingots are to be stacked in piles, the ingots may be transported conveniently by means of a low, two-wheeled, tilting hand buggy. At one plant, where 2 S is rolled directly from the moulds, the ingot is pulled out of the mould and thrown on the buggy. The buggy is then trundled to a roller conveyer, which feeds to the hot mill, and the ingot is dumped on the conveyer.

At another plant, where all ingots are pre-heated, the ingots are removed from the moulds and stacked in piles, according to heats, handy to the charging end of a semi-continuous pusher-type furnace. Ingots are loaded into the furnace by hand. At the discharge end hot ingots are pulled out with a hook on to the table of a small wheeled buggy and pushed by hand to the hot mill. The furnace tender stands by with the ingot on the buggy and dumps it on the bed of the hot mill when the roller is ready. At still another plant, ingots are discharged from a continuous pre-heating furnace on to a gravity roller conveyer which leads to the hot mill.

Regardless of the means for delivery, whether by conveyer or by buggy, ingots should be deposited on the hot-mill front bed or on a roller table at one side (adjoining the bed), which is the same height as the bed. So delivered, the ingots can be easily turned as required and put into position by the hot roller, for the first pass. This avoids the necessity for any lifting, which fatigues the operator and reduces the speed of production.

When duralumin and other alloy ingots are discharged from a pre-heating furnace at about 515° C., they may break or crack or, at least be badly marred, if handled roughly. Such ingots may be held in the conveyer carrier or on the extension (beyond the discharge end of the furnace) of the roller conveyer bed until they have cooled to about 475° C. before being transferred to the hot-mill conveyer. The furnace tender will measure the temperature of the cooling ingots with a surface contact pyrometer to avoid undercooling and ensure that they arrive at the hot mill at the proper rolling temperature.

In the next article of this series the hot rolling of aluminium and aluminium-alloy ingots will be discussed.

1 L. J. Krom, "The Overhauling of Metal." *The Metal Ind.* (New York), vol. II, 1913, pp. 521-522.

2 R. J. Anderson, "Aluminium Sheet Production, Part VII.—Ingot-pouring Practice." *Metallurgia*, vol. 4, No. 20, June, 1931, pp. 64.

The Progress of Arc Welding

German and American Practice in the Shipyards

By E. D. Lacy

Great strides are being made in the application of Arc Welding to Ship Construction

ALTHOUGH it is claimed that England is ahead of other countries in all the latest developments relating to welding, it must be acknowledged that the United States of America has in some departments made great strides recently. Certainly, in regard to shipbuilding and ship repair work, considerable developments have been made in America in the application of welding. The enormous amount of expenditure that could be saved by shipyards throughout the world by a greater use of welding was emphasised by Mr. K. W. Owens, Newport News Shipbuilding and Dry Dock Company, Newport News, Virginia. Mr. Owens, who is an authority on arc welding, stated that the savings by arc welding are not confined to the value of the material, or parts saved, but extend to labour and influence overhead. In a shipyard doing a $20,000,000 business annually, savings would amount to $1,000,000 if welding were fully utilised. If all the freight ships of the world of over 1,000 gross tons were welded, $111,150,000 would be saved annually by the owners and operators, or, to put it another way, this saving would make possible a 4% reduction in freight rates, thus benefiting society as a whole.

It is interesting to note that while connected with the United States Navy, Mr. Owens assisted Commander Knox to organise the first welding shop in the Navy, in which all the welding processes were employed. Among the many projects supervised by him at the Norfolk Navy Yard were the comparative construction of riveted and the first completely metal arc-welded battle-towing targets. These welded targets so clearly demonstrated the possibility of welding as a means of lowering the cost of construction, and the tests were so satisfactory, that the United States Government has now given up the construction of riveted targets, and has built seventeen completely welded targets.

In recent years welding has been greatly developed at the Newport News Shipyard. A school for the training of metal arc welders has been established, and about 100 metal arc welders are employed, and it is expected that the force of the welding and cutting department will soon be at least 200 men. All welding and cutting equipment of the company has been thoroughly modernised, and there are, either installed or contemplated, a number of automatic machines for the welding of pipes and containers of various sizes and thicknesses, bulkheads for ships, and for structural work in general.

In this ship construction the Newport News shipyard used welding extensively in the construction of the coast-guard cutter *Northland*, launched on February 5, 1927. Its doors and superstructure are very largely welded ; it has a completely welded rudder, and four seams at the water-line are welded in addition to being riveted in the usual manner, so as to enable the hull to resist more effectively the pressure in Arctic service. Approximately 600 lb. of electrodes are being used per day, and a total of 30,000 lb. was used on the *California*, of the Panama Pacific Line, which was launched on October 1 1927. It is probable that 60,000 lb. of electrodes will be used on her sister ship, the *Virginia*, which is now under construction.

A number of far-sighted men in the United States, seeing that welding was likely to be an industry of the future, combined to form the American Welding Society, which was incorporated in 1919 for putting the art of welding on a sound and scientific basis. This Society functions chiefly through its research department, the American Bureau of Welding, under whose auspices experimental tests take place and results are published.

Corrosion Objection not Upheld.

The main objection to the use of welding in building ships was the corrosion of electric welded metal in sea water. This argument has now proved incorrect, and Mr. J. Bissell, of the Westinghouse Electric Manufacturing Co., while at the Puget Sound Naval Yard, had an opportunity to examine many parts of ships which, having been arc welded, had been in sea-water for various lengths of time. In no instance was the arc metal corroded except where it had been used to build up riveted heads in ships' rudders. Unwelded riveted heads in the same vicinity were also badly corroded.

From a careful examination of the rudder of the United States ship *Arkansas*, it was found that both welded and unwelded rivets on the forward end were corroded, while a few feet along the side of the rudder were several welded rivets, none of which showed any signs of corrosion. It was believed at the time that corrosion was due to the electrolytic action between the steel of the rudder and the bronze propeller, the action being concentrated at the rivet heads.

In order to make sure that corrosion did not take place in connection with electric welded metal, the General Electric Co. held a test in a 12 ft. cubical tank, which was made for the Emergency Fleet Corporation. This tank was exposed to the weather for five years, and a piece was cut out of the side, which included a welded joint. The depth of oxidisation was just the same as on a plate, proving that the welded portion was not more susceptible to corrosion from ordinary weather conditions than the plate itself. The plate was a ½-in. ship plate.

Notwithstanding the advantages and merits of welding, this art has not been adopted in shipbuilding to anywhere near the extent hoped for by its advocates. To some extent this is undoubtedly due to the fact that the executives in a shipyard are more or less influenced by men who do the work, and these men are more or less uninformed about welding, or prejudiced in favour of old methods. The shipowners also are very conservative when it comes to trying anything new which in their judgment might affect the safety of ships at sea. The real cause, however, that is delaying the adoption of welding in the strength members of a ship, lies in the present method of design. The modern ship, with its angle bars and other shapes, is designed for riveting, and the faying surface of most of the flanges of these bars serves no other purpose than to provide a means of riveted connection. With riveting, a caulking edge is, of course, necessary, and the toes of the bars often serve for this purpose, but in welding, the caulking, as well as the connection, is in the weld.

Great strides have recently been made in German shipyards in the use they are making of welding. For instance, the German Reichsmarine has decided to use welding on an extensive scale on their ships, and are, therefore, instructing numbers of their men in the art of this process. It was decided some time ago to build a trial ship by means of a new method of construction which would allow for the extensive use of welding, and enable all joints, including those of the outer parts, to be made by welding.

The Deutsche Werke, Kiel, have recently constructed two 600-ton d.w. oil tankers in which the maximum possible use of electric welding has been made. The fact that the

vessels were not built to the rules of any particular classification—the owners meeting their own insurance—permitted a boldness in design not otherwise possible. The vessels are 133 ft. in length between perpendiculars, by 26·86 ft. in breadth moulded, by 15·9 ft. in depth, with a draft of 12·93 ft. The engines (of 70 b.h.p.) are aft. There are three main oiltanks amidships, with coffer dams separating them from the engine-room and the forward hold. The equivalent Germanischer Lloyd riveted vessel was taken as the basis for initial design scantlings. As, however, for oil-tight work a maximum rivet-spacing of 3½ diameters must not be exceeded, only about two-thirds of the plating is really intact. Theoretically, the adoption of welding should permit of a corresponding reduction in plating thickness. Actually, however, the riveted shell thickness of 8 mm. was reduced to only 7 mm. Only the centre line bulkhead, keel-bar, gunwale-bar, and stern frame shell connections are riveted; everything else is welded. Shell and deck plating were welded in transverse belts across the ship, as the usual need for a shift of butts no longer existed. Frames and bulkhead stiffeners are of the bulb-plate type, and the usual connecting flange of the bulk angle is unnecessary. The centre-lined bulkhead is continuous through the transverse bulkhead. The deck is made without sheer or camber. The vessel was built on an enclosed slipway; this added considerably to the convenience and expedition of the work.

The structural weight, excluding outfit steel of the riveted vessel, amounted to 208 tons, compared with 144·5 tons for the welded vessel. The greatest saving was effected in bars. For example, in the bulkheads the riveted structure had a plating weight of 25·9 tons with bars weighing 14·4 tons; in the welded structure the corresponding weights are 17·9 tons and 3·52 tons, representing economies of 32 and 83% respectively, and a total saving in weight of 47%. So far as cost is concerned, while the cost per ton of steel is higher with welding than with riveting, yet the overall costs for a ship of given dimensions are practically equal; and for equal dead weight the welded ship is actually the cheaper.

Saving Weight.

It has been found expedient to use electric-arc welding in constructing the new German cruisers of the Konigsburg class, owing to the great saving in weight which has been obtained by using this process. A very high grade of steel was selected, and welding has almost completely taken the place of riveting. Thus, in the construction of the German cruiser *Leipzig*, a vessel 180 metres long and having a tonnage of 6,500, welding took the place of riveting.

The Versailles Treaty laid down certain limitations upon the size of Germany's warships. No German armoured ship can be made of larger capacity than 10,000 tons, and no cruiser can exceed 6,000 tons. These limits predicated, of course, corresponding limitations in the size and range of armament, and the motive power of the ships. By the utilisation of this process of construction, the *Leipzig* has been able to increase its dimensions without increasing its tonnage.

The success of this form of construction has been such that Germany has recently built at Kiel an armoured ship of 9,000 tons capacity which will carry six 11-in. guns and eight 6-in. guns, besides smaller batteries. American and British 10-000-ton "Treaty" cruisers can answer that only with 8-in. guns. Weight of hull is no longer the limiting factor for size of guns and motive power. The modern 10,000-ton cruiser, with riveted hull, cannot carry guns of 11-in. calibre. The hull of the *Admiral von Spee*, however, has been welded into one solid body, which not only gives a saving of 1,000 tons of weight, as against riveted construction, but is lighter, and because it is all in one piece, will permit a salvo of 4,000 lb. from her major guns, the concussion of which would have forced the plates and sheared the rivets in a riveted hull.

The welding of warships should, it is confidently believed, give them greater fighting value, higher speed, and more space for housing their personnel.

A Non-Corrodible Alloy.

AN alloy has recently been developed which has definite non-corrodible qualities. It is known as *Batterium Metal*, and consists primarily of copper and aluminium together with nickel and small percentages of other metals. This alloy was developed for use as a non-corrodible acid-resisting metal for the plate terminals of Tungstone batteries. It is of interest to note that car batteries fitted with these terminals were sold under guarantee, yet no failure claim was made under this guarantee.

As a result of the success resulting from the use of this alloy in battery construction, further uses have been developed for its wider application. It is claimed to be the ideal acid-resisting metal for the construction of fractionating columns, stills, extraction and recovery plants, also for general chemical plant. The alloy is suitable for plants dealing with organic acids, alkalies, superheated steam, bleaching, and dyestuff liquids. Evaporator tubes of this alloy worked under high temperatures have proved to be remarkably efficient.

The alloy has exceptional tensile strength and toughness, as is indicated by the following physical properties, which are certified by the National Physical Laboratory:—

Density	7·67
Melting point	1,035° C.
Freezing point	1,035° C.
Tensile strength	35/45 tons/sq. in.
Thermal coefficient of expansion	0·0000162 per 1° C.
Brinell hardness	158/168.
Elongation	35/48% on 2 in.

ELECTRICAL CHARACTERISTICS.

Resistivity	13·21 Microhms c.c. at 20° C.
Relative conductivity	15·21% of copper.
Temperature coefficient	0·080% per ° C.

PHYSICAL PROPERTIES AT HIGH TEMPERATURES.

Temperatures.	65° F.	750° F.
Tensile strength in tons per sq. in.	36·9	23·9
Elongation on 1¼ in.	37·5%	28·0%
Reduction of area	50·5%	23·0%
Yield point	No definite yield point. Extension continuous up to the maximum load.	
Brinell hardness	158/167	

Tests have been carried out on strips of "Batterium" metal at the Royal Technical College, Salford, with the object of determining its resistance to the effect of various corrosive solutions, at different concentrations and temperatures and for different periods of time. The results are shown in the following table, in which the figures represent loss in weight in grammes per square foot of the metal, ⅛ in. in thickness:—

Reagent.	Cold.			Hot.		
	One Week.	Two Weeks.	Four Weeks.	One Week.	Two Weeks.	Four Weeks.
Acetic Acid, 20%	Nil	Nil	Nil	0·21	0·21	0·55
" " 40%	Nil	Nil	Nil	0·42	0·63	0·96
" " 80%	Nil	0·45	1·13	2·95	8·40	16·55
" " 98—100%	2·57	3·50	4·55	2·95	3·27	3·40
Sulphuric Acid, 30%	Nil	Nil	Nil	Nil	0·21	0·21
" " 50%	0·016	0·05	0·08	0·42	0·55	0·79
" Concentrated, 98—100%	1·05	1·35	1·85	8·40	10·50	13·00
Hydrochloric Acid, 10%	0·21	0·21	0·29	1·65	2·30	7·96
" " 20%	0·42	0·65	3·65	12·60	19·00	57·00
" " 40%	16·00	22·00	33·00	46·00	86·00	100·00
Sodium Chloride, 5%	Nil	Nil	Nil	Nil	Nil	Nil
" Carbonate, 5%	Nil	Nil	Nil	0·21	0·29	0·42
" Hydrate, 5%	3·50	4·00	4·40	0·21	0·63	1·05
" Hypochlorite, 2%	5·85	8·00	8·75	—	—	—
" Sulphide, 1%	—	—	—	Nil	Nil	0·71 Gain

This alloy is produced by Batterium Metal and Vislok, Ltd., of Market Harborough, and is supplied in sheets and seamless cold-drawn tubes to all standard gauges and sizes. Extruded rod in round, square, hexagon, and other sections. Any size screws, rivets, nuts, bolts to any thread. Plug cocks, wheel valves and seats in various standard types and sizes. Special or standard acid-resisting utensils for the chemical trade, and machine castings, forgings, stampings, to any weight or design.

Cutting Risers with Oxy-Acetylene

Foundrymen can profitably survey the possibilities of introducing or extending the applications of oxy-acetylene to the work in the foundry.

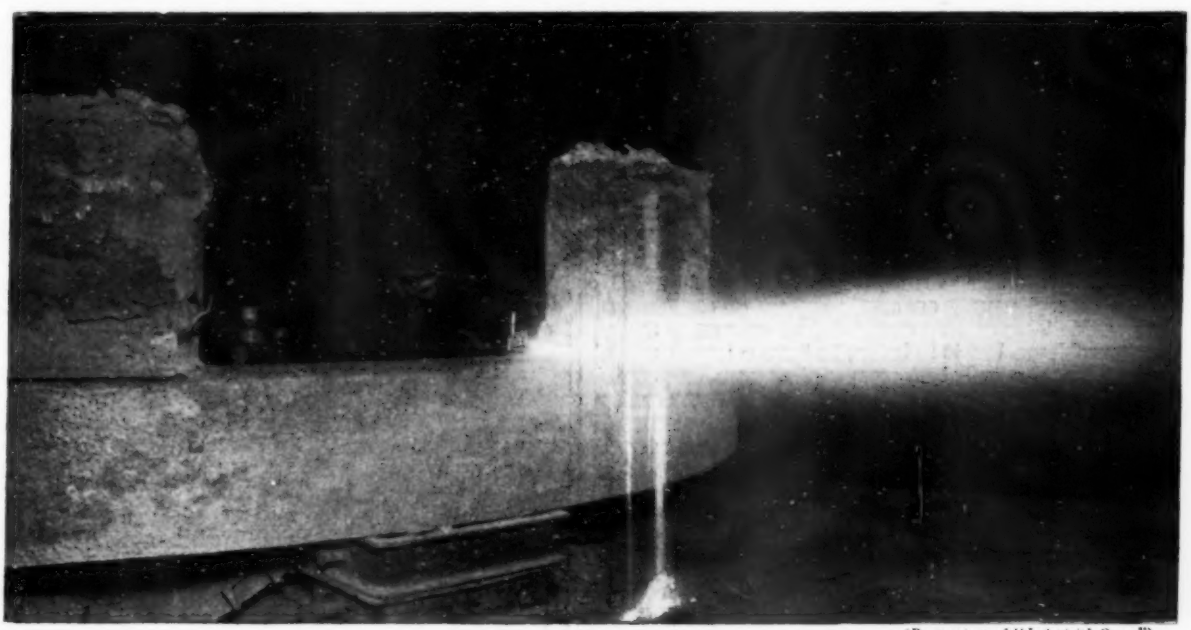
ONE of the great difficulties associated with the production of castings is the development of rapid means for cleaning them. It is frequently assumed that all labour in their production is involved in the making of their moulds and the melting and casting of the fluid metal, but when a casting has been lifted from its mould much labour is still necessary to render it marketable. In some instances, of course, the amount of time required for cleaning is relatively small, while in others more time is occupied in making the casting presentable than has been necessary in the production of its mould. This is particularly true of steel castings, which, owing to the heat of the metal, fuse impurities in the sand, and cause the surfaces to be covered with scale, which must be cleaned off. Apart from this, however, all castings carry added metal in the form of fins or flashes, runners and risers or heads, and these must be removed.

It is in the removal of runners and risers from steel castings that the ingenuity of the foundryman is frequently taxed to the utmost. For many types of steel castings, risers or heads are essential to secure soundness, and the added metal may be so large that it exceeds the weight of the finished casting. Although many steel foundries are equipped with circular saws for this purpose, much time and power is required to cut off the surplus metal, and the use of the oxy-acetylene flame is becoming more general for this class of work.

The development of this cutting torch during recent years has been considerable, and now there is apparently no limit to the thickness of metal capable of being successfully cut with a properly designed blowpipe and a skilled operator. With special equipment cuts have been made through metal between three and four feet in thickness.

In some steel foundries the effect this form of cutting has upon the metal is still a matter of conjecture, although it is safe to say that many investigations have been conducted on this question with the object of determining the influence of the flame on the casting. Obviously, in the cutting process the metal is heated to a very high temperature in the region of the flame, and it was thought that the effect would be injurious to the casting. It must be remembered, however, that the intense heat is localised between very narrow limits and the metal cools very rapidly because the body of the casting conducts the heat away from the cut surface. On this account the extreme edge of the cut, subject to the greatest amount of heat and to a quicker cooling action from the air, is of fine grain structure and somewhat hard. Under the microscope the effect of heat on the grain structure was observed to extend from the cut surface to a depth of about three-sixteenths of an inch, beyond which all evidence of granular metamorphosis seemed to cease. Thus, the hardening effect of the oxy-acetylene flame is apparently localised, and an average machine-tool cut removes all the affected metal.

In addition to the effect on the grain structure, however, the cutting heat is likely to set up strains which may be of a serious character unless adequate precautions are taken to minimise the effect. These strains tend to warp the castings, the extent of the distortion depending largely upon the size and shape of the section to which heat has been applied. With some castings the tendency to warp is considerable, and steps must be taken to overcome the difficulty and preserve the shape of the castings during the time of cutting. Various methods are adopted; in some instances the cut is made gradually, a small section being cut and then the metal allowed to cool before proceeding to cut another small section; in other instances, however, and these are more common, the casting is heated before any attempt is made to apply the torch, and cutting is done while the casting is hot. Whatever method is adopted, it is important that all castings should be thoroughly annealed after the surplus metal has been cut off; this should effectively restore the proper grain structure of the metal, and entirely remove strains. Further, if the casting



(By courtesy of "Industrial Gases.")

Cutting off steel risers, 28 in. by 36 in., in 17 minutes, with an oxy-acetylene cutting torch; oxygen pressure 150 lb. per sq. in. at torch; acetylene pressure, 15 lb. per sq. in.

is skilfully supported, annealing should restore the shape of a warped casting.

Many factors influence successful use of the oxy-acetylene torch for cutting purposes, and the character and condition of the runners and risers are not the least important. Blowholes or shrinkages, cavities common in risers, present a difficulty, and must be overcome by the operator. When a blowhole is encountered, the operator should change his position to permit cutting from the opposite side of the riser; this is better practice than attempting to force a way through an obstruction, and skilful operators can adjust the operation with practically no loss of cutting time or gas. Some operators, instead of stopping a cut when they encounter an obstruction, work round the riser, retarding the bottom of the cut as they advance the torch tip. This tends to increase the width of the cut, and keeps the oxygen jet away from the blowhole until enough metal has been cut away to permit the cutting-jet to work normally on solid metal. The same scheme of cutting round the riser is often used for heavy cutting when the facilities do not permit an ample supply of oxygen for heavy work. This cutting round a riser overcomes many difficult problems, but it is better to have a large enough oxygen jet and a sufficient supply of oxygen to permit straight-through cutting. It is undoubtedly more costly cutting in this way as far as gas consumption is concerned, but the cut is comparatively clean and the subsequent trimming is reduced, which more than compensates for the additional cost of gas.

It is the general practice, with all but small steel castings, to remove runners and risers directly the castings are lifted from their moulds, but before using the torch it is highly desirable that the metal is clean. Even a little sand interferes with the cutting process, and it is advisable to sand-blast the necks of the risers to remove all traces of sand.

When many castings are required to have their risers cut by the oxy-acetylene torch, they should be graded according to size. The bulk may be from two to three inches in thickness, while others may range from six to twelve inches, with a varying assortment of risers of intermediate sizes. In this way the operator can conveniently adjust the flow of gas to suit the various grades, preventing the indiscriminate cutting of risers, which should be discouraged, as the cost may become almost prohibitive. A comparison in gas consumption for different sizes will show why grading is justifiable. In cutting an 8-in. riser, for example, not less than 700 ft. of oxygen and 50 ft. of acetylene an hour will be necessary, and the torch will need to be adjusted for cutting, say, 2-in. risers, as the amount of gas should not exceed 200 ft. of oxygen and 30 ft. of acetylene per hour. Grading the risers into groups, and using tips and pressures best suited for each group, effects considerable saving in the amount of gas used, which more than compensates for the additional labour cost of grading the work.

Some operators consider that excessive gas pressures enable them to cut faster. While it is true that excess of oxygen may have a slight beneficial effect, due to the higher velocity of the gases, which tends to blow the molten oxide from the cut, the slight gain is certainly not worth the oxygen wasted on it: correct pressures are not only economical in the consumption of gas, but better cutting speeds result from their use. Although excessive pressures involve a waste of gas, when they are not high enough the operator will experience difficulties in cutting. Manufacturers of blowpipes generally provide tables showing the pressures recommended for different thickness, and these should be adhered to, as they have only been determined after much experimental work.

(By courtesy of "Industrial Gases.")

Half fly-wheel steel castings after cutting off four risers, each weighing 8,500 lb., with an oxy-acetylene torch.

The blowpipe is, of course, an important part of the equipment, as it is in this apparatus that the two gases are combined for the cutting operation. There are many different makes, but correct designs, good materials, and proper workmanship are the most important factors. Apart from the quality of the blowpipe, it is important that it should be kept in good condition, so that gas passages are clear and joints are free from leakage. A sufficient range of tips should be installed with each blowpipe to cover the variations of work to be done, so that the operator will have the opportunity of changing to suit the work. Many operators have a tendency to use oversize tips, and consequently there is much unnecessary waste of gases.

As a rule, it is advantageous to have the work supported at a suitable height, so that the position of the cut will be on a level with the operator's hips; for this purpose cutting benches or standards should be available to hold the castings. This provision has an important bearing on the economical use of gases, and also promotes clean cutting.

Developments in oxy-acetylene equipment, and in its use for cutting purposes, have shown that it is unsafe to accept limitations for the process, and foundrymen can profitably survey its possibilities with a view to introducing or extending its application to the work in the foundry.

Effect of Temperature on the Properties of Metals

Great interest has been shown in this important subject and much valuable data accumulated in the Symposium in regard to the influence of high and low temperatures on the design and use of engineering materials.

MUCH valuable research work has been done during recent years on the effect of temperature on the properties of metals, and with the object of co-ordinating an interchange of information or ideas relating to the subject, an American Joint Research Committee arranged for a symposium at a joint meeting of the American Society of Engineers and the American Society of Testing Materials, which was held at Chicago on June 23. Considerable interest was taken in the meeting, and in all twenty-seven papers were submitted. In view of the large amount of data accumulated and the limited time allocated to the Societies, it was necessary to adopt a special method of handling the symposium. For this purpose the subject was divided and considered in two phases, and a general review of each was given by a qualified member of the Joint Committee.

At the first session the papers reviewed dealt with the general trend and requirements of metals for various plants operated at elevated temperatures. These were briefly summarised by Mr. L. W. Spring in order that ample time would be available for reasonable discussion of the subject on broad lines. These papers were concerned primarily with the steam boiler and superheating division of the power-plant industry, materials for steam turbines operating at high temperatures, the needs of the oil industry, corrosion, and other problems arising from the use of metals at high temperatures in the chemical industries, the ferrous and non-ferrous metal industries, the automobile industry and the ceramic industry, while the requirements for high-temperature steam piping were also considered. In addition, this section contained papers which discussed the trend of progress in Great Britain on the engineering use of metals at elevated temperatures, and a French view of the mechanical properties of metals at elevated temperatures.

Trends and Requirements for Metals at High and Low Temperatures.

Power- lant Industry.—Research in the power-plant industry is directed towards an increase in efficiency in the energy conversion from the steam at the boiler outlet to electric current, and it is due to the efforts in this direction that increased demands are being made on the metallurgist. This industry, according to Mr. H. J. Kerr, contemplates the improvement of the present efficiency by an increase in the pressure of steam, an increase in temperature of the steam, or by substitution of some material other than steam as the intermediate energy-conveying fluid. These requirements demand special materials, and for higher steam pressures the author gives specifications for two materials for drums, headers, etc., and for tubes, which if met would, in his opinion, enable steam-boiler construction to be developed beyond present standards. Higher superheated steam, particularly with a temperature of 1,000° to 1,100° F., necessitates special material for headers and fittings, as well as tubes, to give continuous life, and desired specifications are given for superheater tubes, for tube elements, and for headers. Mr. Kerr considers that these metallurgical problems are approaching a solution, but he asserts that the power industry must obtain increased efficiency at a cost commensurate with its value.

Steam Turbines.—The problems encountered by the turbine constructor in meeting advanced conditions were briefly reviewed by Mr. R. C. Allen on turbine materials for high temperatures. He concludes that a creep rate of 0·01% per year for the major parts of high-temperature turbines appears to be a satisfactory practical limit. New bolt steels to resist higher stresses than present materials are needed, and higher-grade steels capable of being cast and welded are required for turbine cases. The materials now available for spindle and blading requirements should serve until new limits are encountered. The author considers that much requires to be done in order that the phenomenon of creep may be better understood. Reference was made to the paper prepared by Mr. R. W. Bailey for the World Power Conference in Japan in 1929.

Oil Industry.—The needs of the petroleum refining industry with reference to metals intended for operation under temperature when used for equipment such as stills, cracking units, hot-oil pumps, etc., were discussed in a paper by Mr. E. S. Dixon. Refineries and manufacturers of refining equipment were asked to consider various items of importance to refiners. The replies dealing with stress requirements are summarised and tabulated, but there is some doubt whether or not wall temperatures are metal temperatures or furnace temperatures. The question whether thermal conductivity is an important factor, when considering metals for refinery service, was not altogether maintained, and the opinions on resistance to fatigue as a determining factor were varied.

In regard to corrosion, replies indicated conditions encountered in the oil industry. In the majority of cases it was found that sulphur and sulphur compound corrosion was encountered, while several reported erosion, scaling, acid corrosion, flue-gas corrosion, caustic embrittlement, hydrogen embrittlement, and general corrosion, while some reported hydrochloric acid corrosion. All refiners and manufacturers apparently desire that tubes operated under pressure and high temperature should swell before rupture, though some state this is not imperative provided the material has other outstanding characteristics.

Ferrous Metal Industries.—The application of metals to metallurgical processes was discussed in a paper by Mr. J. C. Woodson, who, in suggestions for the improvement in the manufacture and application of heat-resisting alloys for furnaces, recommends better foundry practice, more fundamental research by the foundries into the chemistry and metallography of heat-resisting alloys, the development of test data that are practical and reliable, and closer co-operation between designers and suppliers of alloys.

Non-ferrous Roasting, Smelting, and Refining Industry.—The requirements of apparatus and equipment for processes applied to the treatment of ores and concentrates involves problems in the selection of materials. The plant required in ferrous and non-ferrous metallurgy are similar in their general corresponding functions. In each case it is subject to operation at high temperature, with resultant deterioration and destruction by high-temperature oxidation, loss of strength, creep, growth, or other distortion. In the selection of construction materials, however, the builder of non-ferrous metallurgical plant must also contend with the problem of high-temperature chemical corrosion more intensively than the builder of an iron and steel plant.

Chemical Industries.—The requirements of materials used at high temperatures were considered in a paper by Professor F. H. Rhodes, in which he stated that they

should not decrease markedly in strength when hot, nor show a pronounced tendency to "creep" or to distort under load, and they should not oxidise readily nor show marked increase in grain size. Additional requirements are necessary for these industries, because materials are not only subjected to heat and mechanical stress, but also to the action of substances that may react chemically on the metal. In processes that involve working with acids, alkalies, or corrosive gases, consideration must be given to the effect of temperature upon the rate of corrosion as well as its effect on the physical characteristics of the metal. Furthermore, many reactions effected at high temperatures involve high pressures, and the combination of the effects of heat, pressure, and chemical action may cause more rapid failure than would be brought about by any one factor.

Although this discussion was concerned primarily with the corrosion problems of a few chemical industries, the chemical-plant engineer is also confronted with structural problems. The high temperature, high-pressure catalytic processes for the synthesis of ammonia and methanol, for example, involves design difficulties, even if all corrosive attack on the container were eliminated.

Steam Piping.—A paper dealing with piping, valves, fittings, bolts or studs, nuts, and the component parts of valves, was presented by Mr. F. W. Martin, in which he stressed the need for materials to be used at temperatures above 750° F. to be divided into three classes—between 750° and 850° F., 850° and 1,000° F., and those for use above 1,000° F. Materials to be used at these temperatures should have, at the temperature under consideration, physical properties permitting the same unit stresses as are now used in materials up to 750° F. Pipe and fittings can be allowed a creep of 3% in 200,000 hours with safety. Valve bodies and parts must be held to closer limits of total deformation because of the movable parts. The author considers that studs of alloy steel are necessary in all high-temperature installations.

Ceramic Industry.—The use of metals at elevated temperatures in the ceramic industries is confined largely to drying and firing operations. In the drying operations at temperatures between 300° and 500° F. the gases resulting from the firing processes are usually sufficient to cause corrosion, while drying gases contain dust, which causes abrasion. In most cases, however, the corrosion and abrasion are not severe enough to warrant special resistant alloys. The firing of ceramic ware, whether by periodic or continuous car-tunnel kilns, has a greater effect on the metals used. The temperatures to which the various products are heated range from 1,600° to 2,200° F. for heavy clay, to about 2,775° F. for chrome and silica brick. Metals used in the construction of these kilns and in cars, supporting racks, sand-seal plates, pans and trays, kiln doors, dampers, goose necks, fans, etc., are therefore subjected to high temperatures, to stresses set up by alternate heating and cooling, and to the oxidising and corrosive action of the combustion gases.

Somewhat similar conditions exist in the furnaces for vitreous enamelling, and metals used in their construction must resist the strongly oxidising and corrosive combustion gases, must possess mechanical strength at the high working temperature, and must not lose their strength or become brittle after long-continued use. The coefficient of expansion of such metal should not be too great, and must be accounted for in the design. Any metal that faces the working chamber must be non-scaling, to prevent contamination of the ware being enamelled.

Automobile Industry.—The requirements for automobile and Diesel engines were reviewed by Messrs. A. L. Boegehold and J. B. Johnson, who made comparisons between available materials for various parts subject to high temperatures. In regard to pistons, the authors state that the automobile industry will welcome an alloy which possesses the specific gravity, thermal conductivity, and machinability of aluminium alloys, with the hardness, wear resistance, coefficient of expansion, and low cost of cast iron. The problems associated with materials for Diesel engines are different from those encountered in petrol engines; construction trends are towards the use of higher strength materials for cylinder blocks and heads. In regard to aviation engines, the emphasis on low ratio of weight per horse-power leads to refinements in design and resultant high working stresses, which involve materials of great strength and low specific gravity. The operating temperatures of cylinders, pistons, and valves are relatively high, and the use of anti-knock compounds introduces corrosion problems and these must be considered in the selection of suitable materials.

Progress in Britain.—The British contribution to this symposium was a very comprehensive paper dealing with the trend of progress in Great Britain on the engineering use of metals at elevated temperatures, prepared by Messrs. R. W. Bailey, J. H. S. Dickenson, N. P. Inglis, and J. L. Pearson, who state that the satisfactory and economic design of plant, including steel parts subjected to high pressure, elevated temperatures, and possibly chemical reactions, involves the use of materials having the following qualities:—(1) The steel must have good strength at high temperatures—that is, a small rate of creep under a comparatively high stress. (2) It must be resistant to the corroding or disintegrating media involved by service conditions. (3) It must retain its original properties after long periods under stress and temperature, and must not be susceptible to change under various rates of heating and cooling, even if frequently repeated. (4) It should present no unusual manufacturing difficulties to a steel-maker accustomed to the production of special steels. (5) In the case of chemical plant, it should be weldable by all methods of welding, and heat-treatment after welding should not be essential. (6) It should be inexpensive.

A combination of these good qualities is at present unattainable, and in general the material chosen for a given service shows superiority in such of these requisites that are most essential. With regard to strength of metals at elevated temperatures, British research has been devoted to carbon steels, high-tensile strength alloy steels, chiefly of the pearlitic class, and nickel-chromium alloys.

Mechanical Properties of Metals at Elevated Temperatures.—The necessity of knowing more exactly the true properties of metals over a large range of temperatures, and of determining them quantitatively with more precision, is evident, and much attention has been given to the problem. The results of some researches on this problem, which have been carried out at the laboratory of the Société Anonyme de Commentry-Fourchambault et Decazeville, installed at the Imphy Steel Works since 1913, were given in a paper by Professor Pierre Chevenard. In the first section he indicates how the study of internal friction allows one to appreciate the difference between a metal and a perfectly elastic solid. The possible methods of studying viscous deformation are then classified, and the principal results furnished by two of them are presented. Finally, after having reviewed the industrial applications of these studies, he discusses what we understand to be the mechanical properties of metals at high temperatures, as well as suitable methods for determining them. The author concludes that researches on the mechanical properties of metals at high temperatures have already resulted in important applications. But patient researches are still necessary to determine the exact laws of permanent deformations, temperatures, and stresses, and to clarify the influence of numerous physico-chemical reactions which are taking place concurrently in a specimen maintained under tension at high temperature. A more thorough knowledge of these laws will permit us to perfect heat-resistant alloys and to utilise them with more security and economy at still higher temperatures, to the great advantage of the mechanical and chemical industries.

Properties of Available Metals for High- and Low-Temperature Service.

The papers presented for discussion at the second session were reviewed by Mr. H. J. French, the chairman of the Joint Research Committee. They concerned the properties

of available metals for use on high- and low-temperature service, and embraced both ferrous and non-ferrous metals. A consideration of zinc and its alloys, by Mr. H. A. Anderson, showed the extent to which this metal is used. Although the common applications of zinc do not involve its use at other than approximately normal temperatures the author has found it possible to abstract references from various investigations which contained data on high- and low-temperature characteristics.

Aluminium and magnesium alloys are often used under conditions where they are subjected to the effects of temperature, and the problem of defining the mechanical properties of a number of alloys in use was discussed in a paper by Messrs. R. L. Templin and D. A. Paul. Mr. E. R. Darby discussed the properties of bearing metals at normal and elevated temperatures. He classified them as copper-base alloys, the white metals and the ferrous alloys, and much valuable data is associated with this paper. The results of short-time tests at elevated temperatures up to a maximum of 1,832° F. are recorded, in a paper by Mr. W. B. Price, on the properties of copper and some of its important alloys, with the object of setting the proper limits for hot forging, extrusion, and other operations where a close temperature control is desirable.

The performances of cast-carbon and low-alloy steels in high- and low-temperature service, with special reference to the consuming industries were discussed by Mr. R. A. Bull. In the low-temperature fields he regarded it as certain that the product of the steel foundry would increase in variety and tonnage, and the nlargeing volume would result in more carefully assembled evidence to demonstrate what grades of steel are best to use in castings for low-temperature service. The properties of grey iron and malleable cast iron are discussed by Messrs. J. W. Bolton and Hyman Bornstein, and special attention is given to growth of grey iron and the superior properties of alloy cast irons. The common alloys of wrought austenitic type used widely at high temperatures possess compositions lying generally within—

Chromium	16.0 to 30.0%
Nickel	7.0 to 30.0%
Carbon	0.05 to 0.20%
Silicon	0.30 to 2.50%

Other elements are sometimes added for various reasons, but in the main the properties are achieved through the alloying of the elements mentioned. These alloys form the basis of a paper by Messrs. R. H. Aborn and Edgar C. Bain. In the consideration of metals and alloys, strength and susceptibility to corrosion may probably be regarded as dominating in importance; one cannot be considered without reference to the other, and their relative importance to each other may change greatly in passing from one condition of use to another. It is upon these two characteristics that principal attention is devoted by Messrs. N. B. Pilling and R. Worthington, in their discussion of the iron-chromium-nickel alloys, while the nickel-chromium-iron group is considered by Messrs. C. A. Crawford and R. Worthington. Considerable data is presented in a paper by Mr. C. E. MacQuigg on high-chromium steels. Only those steels are considered that are applicable to extreme conditions of service with respect to high temperatures, abrasion, and corrosion. The properties of rare metals have not been overlooked in this survey, and Mr. W. H. Swanger reviewed the economic and industrial importance of gold and platinum, both of which have long been known to withstand deterioration when heated in air at any temperature below their respective melting points. Silver is also included in the discussion, as well as the metals ruthenium, rhodium, palladium, osmium, and iridium, which together with platinum constitute the platinum group of metals. In addition, tungsten, molybdenum, tantalum, and columbium are considered as rare metals, with useful properties at elevated temperatures.

Special interest is presented by nitrided steels, because of the fact that they can be made to have a higher order of hardness than high-speed and case-carburised steels, and therefore present possibilities of supplying a material which will retain an unusual order of hardness, even at elevated temperatures. This subject was discussed by Mr. Oscar E. Harder.

In the low-temperature region, changes of state, structural changes, and surface modifications are of rare occurrence in metallic substances. Only slight industrial use is made of metals at low temperatures, and as failures in such cases are infrequent, there has been no great demand for knowledge of the properties of materials in this condition of temperature, but in modern refrigerating practice aircraft subjected to extreme cold, the transportation of liquid air in metal cars, the laying of rails in the Far North, as well as other developments in which materials are subjected to low temperatures, will cause the user of such materials to inquire into their properties at low temperatures. There has, of course, been some valuable work done on this subject, notably that of Hadfield and Dewar in 1905, published in the *Journal of the Iron and Steel Institute*, vol. 67, page 147 (1905). The work by Mr. H. W. Russell in this symposium summarises the available information on the properties of metals and alloys.

Some published and previously unpublished data on the expansion properties of metals are contained in a paper by Mr. N. L. Mochel. Expansion is a factor that must be given consideration in practically any engineering construction, whether the parts are stationary or otherwise in their service. The provision for expansion is a problem at comparatively normal temperatures when materials are subjected to varying conditions through the seasons of the year, but as higher temperatures are approached, it becomes a graver concern and of greater difficulty. The application of data on the thermal conductivity of metal is presented by Mr. M. S. Van Dusen, in which he points out certain fundamental ideas common to all processes where heat transfer through metals is involved.

This symposium has provided a very comprehensive survey of the trend of progress in various fields on the effect of temperature on the properties of metals, and while it was impossible to discuss the subject adequately during the short time available at the joint meeting, much written discussion is bound to arise which cannot but be profitable to all concerned in engineering progress.

PERSONAL.

Mr. G. C. Coppel, Managing Director of J. J. Saville & Co., Ltd., Triumph Steel Works, Sheffield, we are informed, will retire from active business at the end of July.

Mr. Coppel, who has been actively engaged in the manufacture of steel for over 50 years, is one of the leading authorities on steel-making; during this period he has played a distinguished part in building up Sheffield's unique reputation for high-speed and other classes of alloy steels. He has travelled very extensively, his knowledge of foreign trade being unique, particularly of Russia and Continental countries, and his work in this field has been a principal factor in the development and growth of J. J. Saville & Co., Ltd.

A few years ago, at a time of life when most men would be contemplating relaxation from duty, Mr. Coppel accepted the Managing Directorship of Messrs. Wm. Jessop & Sons, Ltd., Brightside Works, Sheffield. Mr. Coppel will now also retire from Jessops, and in his retirement has the good wishes of all connected with the two firms mentioned and of a wide circle of personal and business friends at home and abroad, and it will mean a distinct loss to one of the most important sections of Sheffield's industry.

Mr. W. F. Chubb, who occupied the position of Chief Metallurgist to Messrs. Henry Ford & Son, Ltd., has vacated his position and is now available for reappointment.

APPOINTMENTS.

Dr. W. Rosenhain, F.R.S., who recently resigned his position as Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory, has been appointed as consultant and metallurgical adviser to the Broughton Copper Company.

Mr. F. C. Yapp, who has for many years been associated with Messrs. Vickers-Armstrongs Ltd., has been appointed a member of the Board of this Company.

Reviews of Current Literature.

Journal of the Institute of Metals. Volume XLV.

THE forty-fifth volume of the *Journal of the Institute of Metals* is notable in that it constitutes the first of the long series of these volumes to be published without abstracts. "Proceedings"—as the impress upon the cover of the new journal suggests—constitute the sum and substance of "No. 1, 1931," of this invaluable metallurgical publication. The issue month by month of the abstracts that were formerly incorporated with the half-yearly proceedings has had the effect of halving the size of the Journal. It has also accelerated the work of publication, for the smaller volume now appears in the middle of June instead of—as in former years—in August. This earlier publication must be of value not only to the contributors of the many important original scientific articles that appear in the Journal—who naturally desire their work to secure the earliest possible publicity in the transactions,—but also to those persons engaged in metallurgical and engineering work who are anxious to consult with a minimum of delay the latest scientific information of the type that is rendered available by the Institute of Metals through its proceedings.

The volume under review contains a fully illustrated record of the striking annual May lecture which was delivered before the Institute of Metals on May 6 by Mr. William B. Woodhouse, past-president of the Institution of Electrical Engineers, on "The Progress of Power Production." All the papers read at the annual general meeting of the Institute held in London on March 11 and 12, are reproduced, together with the discussions that took place upon each paper at the meeting and the many important written contributions to the discussions that have been subsequently received. In each case the authors' replies to the criticisms of their work are now included, thus adding considerably to the value and interest of the records contained in the transactions. The papers that are dealt with in this manner number fourteen in all. They range from the consideration of such practical matters as rolling copper, the extrusion of metals, and the resistance of superduralumin to corrosion by sea-water (the latter notable piece of work being by a distinguished German metallurgist), to such semi-historical discourses as those on the microstructure of early Greek silver coins—this by a woman metallurgist,—and the corrosion of early Chinese bronzes.

Pp. 442, with 59 plates, 3 folders, and numerous illustrations in the text. Cloth. Edited by G. Shaw Scott, M.Sc. 1931. London: The Institute of Metals, 36, Victoria Street, London, S.W.1. (Price, 31s. 6d. net per volume. Subscription price £4 per annum (3 vols.).

Mechanical Testing.

Testing of Materials of Construction.

IN designing structures it has always been customary to consider the best distribution of available material likely to give the greatest strength, but during comparatively recent years other factors in addition to strength must be considered. Reducing the dimensions of structures consistent with safety, more economical power-weight ratio in prime movers, and increased steam temperatures and pressures have developed complex problems, and it is essential that the designer should have available all information that will enable him to use materials to the best advantage. This information is obtained as a result of tests on materials of known composition from which the values of physical constants are obtained which facilitate the work of the designer.

It is the work of the scientific investigator to supply data in order that his theoretical researches may be applied to the problems encountered in engineering practice. Absolute results concerning definite properties of materials form the basis of scientific testing, but as the determination of the values of physical constants is usually slow, laborious work, involving considerable skill and scientific ability, approximate tests have been devised, in some cases approximating closely to the scientific tests, which are only intended to give a comparative indication of the physical properties of the material. It is the results expected from these approximate tests that are generally inserted in a specification.

The changes in methods employed in testing materials caused the authors to prepare a treatise in two volumes; the object being to discuss the conditions governing modern testing, to give particulars of standard testing plant and its limitations, together with such information as would enable results obtained to be appraised at their true values.

This treatise has now become a standard work on the subject, and, as a result of considerable recent progress in standardising methods of testing, a second edition of the first volume of this treatise has been published. The British Engineering Standards Association have recently issued specifications on Brinell hardness numbers, methods of testing timber, test methods on grey-iron castings, notched bars tests, etc., which have been included in this edition, while many of the recommendations given in the first edition have been embodied in B.E.S.A. specifications. Rapid advance has been made in fatigue testing, hardness testing, and the testing of materials at high temperatures, and the opportunity has been taken to enlarge the chapters dealing with these subjects. It is interesting to note that the authors have also incorporated suggestions which have been received from experts in different parts of the world.

The book is essentially practical in its direct application, but it embodies the scientific explanation also, and it has been included in the publishers' directly useful technical series of works, which occupy a midway position between the theoretical and practical works. This edition will be appreciated as an invaluable aid to designers, technical engineers, manufacturers and students, as well as to those whose duties necessitate some form of commercial testing to determine whether materials conform to the terms of specifications. It is avaluable work, and those who desire to keep in touch with recent developments in mechanical testing will appreciate this informative book.

By R. G. Batson, M.Inst.C.E., M.I.Mech.E., and J. H. Hyde, A.M.Inst.C.E., M.I.A.E., A.M.I.Mech.E. Published by Messrs. Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price, 21s. net.

Institution of Engineers and Shipbuilders in Scotland.

THE "Transactions of the Institution of Engineers and Shipbuilders in Scotland" for June, 1931, contain a discussion on a paper entitled "Motor Yachts," by J. R. Barnelt, O.B.E., and also two papers with subsequent discussions. The first of these is entitled "The Design and Construction of Flying Boats," by A. Gouge, B.Sc., and deals with every detail of hydrodynamic and aerodynamic design. The second, by F. A. Willcox, D.Sc., and J. D. Farmer, discusses "Some Considerations Affecting the Design of Refrigerated Vessels."

Institution of Mining and Metallurgy.

IN addition to reports of various discussions, the *Bulletin* of the Institution of Mining and Metallurgy for May, 1931, contains reports of speeches at the annual dinner of the Institution, and also the fortieth annual report of the Council. Technical matter in this issue includes a discussion on Mr. C. B. Brodigan's paper on "Rand Mining Practice," further contributed remarks on "The Sampling and Estimation of Bore-hole Cores and Sludges," by D. K. F. MacLachlan, and on "The Use of Hole-directors in Ground-breaking Control," by H. Simon, and also the authors' replies to discussions on "Water Concentration Tests" and on "Clay Mining in South Devon."

Steel Furnace Repairs

By Walter Lister.

Apart from quality of output much skill and resourcefulness are necessary to keep a furnace in commission as long as possible.

AN important fact to be borne in mind is that while a furnace is under repair it is earning nothing. Actually it is losing money through loss of time, and, in addition, it is absorbing, in the cost of new brickwork, some of the money it made while in commission. Therefore, apart from the quality of output, the art of profit-making consists in keeping the furnaces in commission as long as possible, and shut down for repairs as little as possible.

Much can be done to help in both directions. As regards the former, we will consider the hearth first. If this is not kept in good condition from tap to tap there will be endless stoppages of a few hours or so at a time, and in the end (which comes sooner than it should) the furnace will have to be shut down for two or three weeks in order to put in a new hearth, which means practically rebuilding the furnace.

Repairs to the Hearth.

As soon as the furnace is empty the bottom should be tried with an iron rabble. There may be pools of steel here and there, but it does not follow that these are holes. They may be caused by high places on the bottom preventing the steel running out. These high places are usually accumulations of lime. The hearth should never be raised by more dolomite to the level of these places. On the contrary, the high places should be removed by putting on them a few shovelfuls of mill scale just before charging again. The next time the furnace is tapped the charge will run out completely and leave the bottom dry. If not, more scale should be put on until it does.

A high bottom reduces the capacity of the furnace, and consequently the output, to say nothing of the danger of a break-out with an extra heavy charge. But, on the other hand, if the bottom is normal, and there are pools of steel left in the furnace after tapping, they are the result of corrosion, and should be carefully watched. If they are not more than, say, half a rabble deep, they can be left till the mid-week dry-up, but any holes deeper than this should be immediately splashed out and the bottom made up again. Any fresh repairs should be well burnt in, or the time expended on the job will be wasted, and it will all have to be done over again, with probably a deeper hole the second time.

Most holes begin in a very small way, and if these small beginnings are promptly nipped in the bud, no serious trouble is likely to develop. It is only when bottoms are neglected—not splashed out properly, and made up again on top of steel—that continuous stoppages due to bad bottoms occur. In this case the smallest boil on the bottom quickly develops into an upheaval, and in a few minutes a huge hole develops which may take four or five hours to repair. Leaving " old dogs " in the furnace is a fruitful source of " break-outs." A box of dirty scrap, for instance, may cut out the thin layer of dolomite on top of the " old dog." This boils out, and probably connects up with another one. Very soon there is a general upheaval, which may end in the charge going through the bottom.

When a hearth is known to be dangerous through this cause, there is always a feverish desire to get the charge tapped whenever the least sign of a boil commences. This often results in a cast that is no use for anything on earth, even if it is not all actual scrap. For this reason, among many others, it cannot be too strongly impressed on the furnacemen that all deep holes must be splashed out completely dry in the first place, and on no consideration whatever should any attempt be made to make up the bottom again until this is done.

If the hole is too deep to be dried up in the ordinary way, the tap-hole should be cut down to the lowest possible limit. For this purpose it is best to take the lander off and substitute a short, temporary one in a lower position, or even build up a makeshift with a plate and a few bricks. Wooden rabbles are always best for splashing out, as being lighter, the heads can be made larger, and thus have

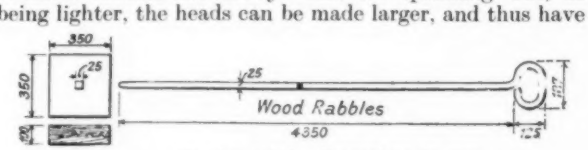


Fig 1.—Wooden rabble, dimensions in mm.

a greater pushing surface. Moreover, wooden rabbles do not chill the steel so much, and the operation is thus rendered much easier. These rabbles are more easily made, and are much cheaper than iron ones. If a supply of heads is kept, these can be knocked on to the shank in a few seconds and wedged on tight with pieces of thin scrap.

For repairing a bad hole it is always best to riddle the dolomite and discard the fine powder. Anything above, say, $\frac{3}{4}$ in. cubes should also be discarded. This and the powder can be used up in the ordinary way of fettling. Clean dolomite, and not too big, is the best. If it is well burnt in, a little at a time, the job will be satisfactory, and the bottom as good as new once more.

A new repair should always be well slagged at a good heat, after which the gas should be taken off for an hour or so to harden the new dolomite. On heating up again, the repair will be found to have a higher fusing temperature than before.

Repairs to the Tap-hole.

After cutting down or washing out, a new tap-hole will have to be made. This is best done by using a steel pipe of the necessary dimensions as a template or plug. When the hearth has been made up level with the original bottom of the tap-hole, and the lander refixed in position, the pipe (which should previously have been filled with dolomite and coal mixture) is inserted so that the lander end is about 6 in. inside the hole.

As soon as the pipe is in position, filling-in can commence. For the front side, a mixture of 50% dolomite and 50% pea-size magnesite should be used. This should be well mixed with hot tar. A little should be thrown in with hand shovels, and then pressed in with an iron rabble, after which more can be thrown in until the job is finished. The mouth of the pipe should be well covered with the tarry dolomite, and then a little dry dolomite and a shovel or two of lime to make it secure for charging. When the tap-hole and bank above are once more in a normal condition, full gas should be kept on for at least one hour, in order to burn the new dolomite well in. After this, clean crushed slag should be thrown over the repair. When this has melted and soaked in, say, half an hour, charging can commence.

To go back a little, at the same time as the front side is being repaired by the first and third hands, the second hand, with the help of a labourer or fourth hand, should be ramming the back or tapping side. They should commence to do this as soon as the pipe is in position. The material for this purpose should consist of 50% dolomite, 25% pea-size

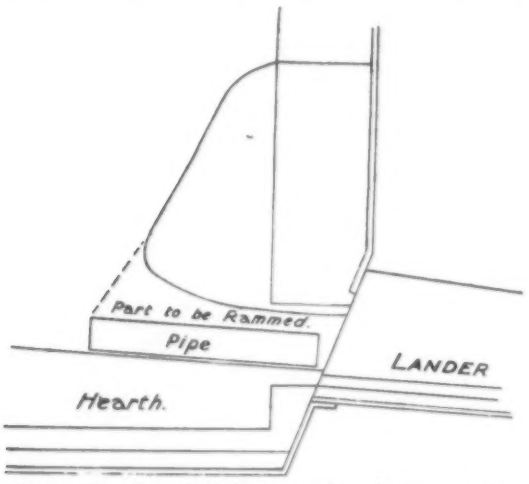


Fig 2.—Tap-hole with pipe inserted ready for ramming.

magnesite, and 25% finely powdered magnesite. The finely powdered magnesite is necessary in order to make the material plastic enough to stand up when rammed. Pea-size material alone is no use, as it falls down immediately the ramming tool is taken away. The material should be well rammed all round the pipe and as far as the end of the pipe. The hole is then completed by ramming in plastic ganister or fireclay.

It sometimes happens that it is not necessary to make an entirely new tap-hole; the front or charging side only may have boiled out. In this case a short pipe should be inserted, as shown in the illustration Fig. 3. Tarry dolomite is thrown in the cavity left, and pressed in with a rabble until the repair is complete. The back side can at the same time be closed in the ordinary way with coal and a fireclay stopping. When the repair has been well burnt in and slagged, charging can commence. This should not delay the furnace more than half an hour.

If, owing to cutting steel out, or other causes, the back side becomes dangerously big, this part can be repaired by means of a short pipe also, as shown in the sketch Fig. 4. The mixture previously mentioned should be used. A repair of this nature need not delay the furnace at all. The hole can be closed in the ordinary manner at the front side, rammed with coal as far as the part to be repaired, and then charging can go on while the remainder of the operation is being carried out.

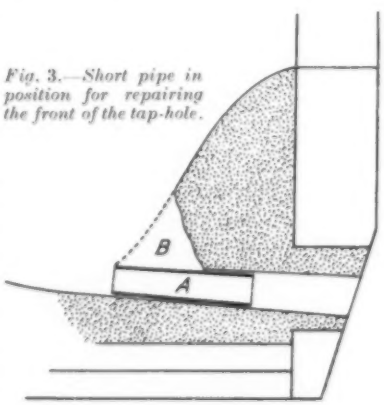


Fig. 3.—Short pipe in position for repairing the front of the tap-hole.

The foregoing remarks apply also to acid furnaces. The same care must be taken in splashing out and fettling, or the same troubles will arise. The tap-hole can be repaired in the same way, except, of course, in the matter of the materials. In the case of the acid, good-quality sand should be used for the hearth and the front of the tap-hole, while plastic ganister or other good-quality fireclay should be used for ramming at the back.

Repairs to Door Jambs and Arches.

Where water-cooled doors and jambs are not installed, there is always a lot of wear and tear on the brickwork, especially in cold charging. The charging machine is to a large extent responsible for this, as in going in and out so many times, and slewing round in order to place the charge as compactly as possible, chips of brickwork are continually being broken off, until the walls are too weak to sustain the arch, and then, with a slight touch, down comes the first ring of the arch, soon followed by the others. A good way to preserve the brickwork as much as possible is to build the door jambs with splayed corners, and set at a slight angle, opening out to the inside of the furnace, as shown in the illustration Fig. 5. By this

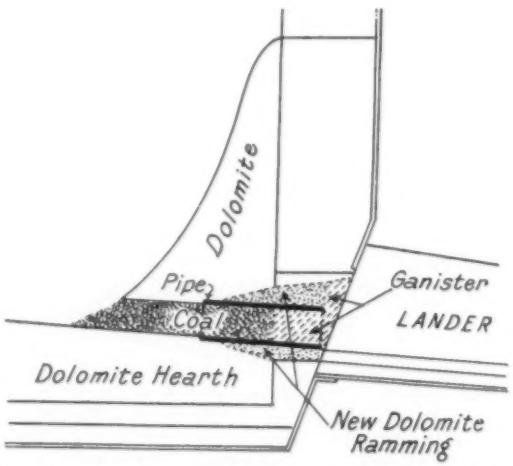


Fig. 4.—Method for repairing back side of the tap-hole.

method there are no sharp edges to be knocked off, and the charging machine has a larger radius in which to operate. But even with the greatest care, door jambs and arches require repairs before any other part of the brickwork. And these repairs should always be carried out before there is any danger of burning the buck-stays or arch plate concerned. The furnaces should be examined at each week-end for minor repairs of this sort.

The best way to proceed to put in new jambs and arches is to pull the door to one side just sufficiently to allow of the old jamb to be cut out and a foundation

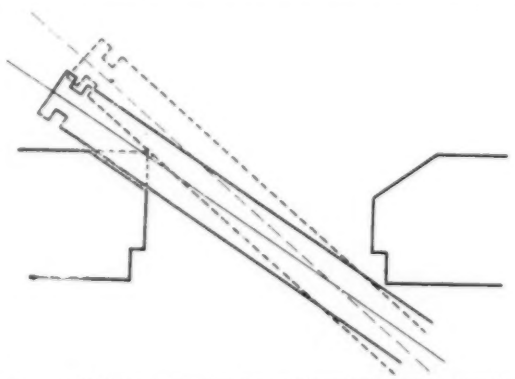


Fig. 5.—Method for preserving the brickwork of the charging door.

made for the new one. When this is done, the other side can be treated the same way. After that the door should be pulled up to its fullest extent, and the opening blocked with bricks loosely laid so as to leave just enough room for the rebuilding of the jambs. When these are finished the arch can be put in by using a piece of steel plate, bent

to form the template. One bricklayer and a labourer should do this job in an hour.

If it is considered advisable to carry out this repair between casts, the furnace should be charged first in order to cool it down a little, and if the gas and air are also screwed down a bit, the job can be carried through without loss of time. All bricks for jambs and door arches should be first soaked in boiling tar before use. This prevents them chipping on contact with the heat, and also gives them a greater resistance to an accidental bump from the charging machine.

The Back-Lining.

This also often requires repairing at the week-end. The most vulnerable part is in the centre, just above the tap-hole. But very often this part becomes thin from other causes besides fair wear and tear. Carelessness in throwing up dolomite during fettling, or feeding mill scale and fine iron ore, can be responsible for much damage here. When dolomite is thrown up too high, it naturally corrodes the silica wall, and the resultant slag runs down and cuts out a cavity between the dolomite bank and the wall. This is probably filled in after the next charge, with more dolomite, and the same thing happens. The silica wall recedes farther and farther away from the bank after each successive charge, until there is hardly any left, and it is necessary to put in a yard or so of fresh brickwork. The same thing happens with mill scale, and in this case not only the silica wall, but the dolomite bank also, is cut away. The result of this may easily be that a serious boil will develop dangerously near the tap-hole.

Dolomite should never be thrown on to the top of the bank. If a cavity forms, it should be filled in with magnesite or chrome ore, but never dolomite. A good practice, when putting in a new bottom, is to finish the top of the bank with chrome ore or chrome bricks. Although a little more costly, this material is much more refractory than either magnesite or dolomite, and the extra expense is always justified by the longer life of the brickwork.

Roof Repairs.

During a run, a patch is often required in a roof. The parts most affected are about 4 ft. from the ends, and above the gas ports. But this also is very often due to carelessness and neglect in not cleaning out and levelling

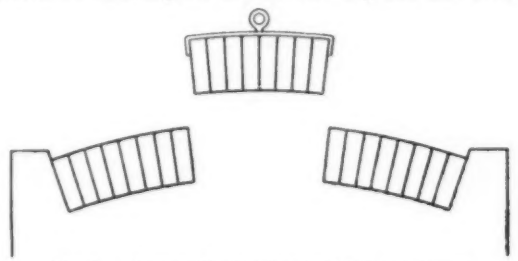


Fig. 6.—Clamp of bricks for repairing hole in roof.

up the gas ports. Owing to the passage of the gas being impeded by bricks, or perhaps a hole just inside that should have been levelled up, the gas is deflected up to the roof like a blow-pipe flame, and very soon a hole is burnt through. So that really, with proper care, there should be no patching required, and the roof should wear to a uniform state of corrosion, due to old age, over the whole of its area. But, unfortunately, the human element is often found wanting, and flames sometimes make their appearance through an otherwise perfectly good roof. When this happens, the place has got to be patched. If the charge is in process of working down, a clamp of bricks can be laid on top of the bad place until the charge is tapped. Afterwards, the place can be cut out to allow of a clamp of bricks being dropped into position to fill the aperture, as shown in the illustration Fig. 6. A clamp consists of a convenient length of flat steel bar about 1½ in. by ½ in. The ends are bent down about 2 in., and a lifting hook is fixed in the centre. Five or six bricks (according to the size of the hole to be repaired) are fixed in the clamp and wedged tight. Two or three clamps may be required to complete the job. Care should be taken to see that they fit tight in the hole, or they will fall into the furnace when the clamps are removed.

Electric Furnace Repairs.

The hearths of electric furnaces suffer mostly just underneath the electrodes, and pools of steel are usually found here after the furnace has tapped. This corrosion can always be expected, but it can be minimised to a large extent by continually pushing unmelted scrap underneath the electrodes. This prevents the arc from playing on the bottom and so melting out the dolomite. This applies more particularly to basic conductive hearths. Acid hearths do not suffer so much in this way.

It is rather difficult to "splash out" a deep hole in an electric-furnace hearth, but a lot can be done in this respect with regard to the two electrodes nearest the tap-hole. Any steel left in will have to be raked out with iron rabbles. The two electrodes farthest away usually drain out when the furnace is tilted to its utmost limit for tapping, and these seldom give much trouble. The other two are the most difficult to deal with, as the furnace seldom tilts over as far on the slagging side. To get steel out of a deep hole dolomite should be thrown in and puddled up with the steel, so that the resultant pasty mass can be raked out clean. For fettling, a mixture of dolomite and magnesite in equal proportions should be used, but as this is very refractory, and the residual heat of the furnace is not sufficient to calcine it, some less refractory material should be mixed with it in order to bind it sufficiently compactly to stand the first charge. The best material for the purpose is good basic open-hearth finishing slag. Electric slag usually contains too much fluorspar, which renders it unsuitable for this purpose, the remedy being worse than the evil in most cases. When the repair is finished, a few shovelfuls of the slag should be thrown over the top.

Repairs to Walls and Roof.

As the heat generated in an electric furnace is confined in a very small space, with no chimney outlet, the corrosion of the silica brickwork is naturally very severe—much more so than in the open-hearth. When side walls get thin, they have got to be repaired in the least possible time between casts. It is always best to do this without removing the roof, as this will act as a shield to protect the men from the heat. The first thing to do is to take out a few roof bricks immediately above the place to be repaired; the wall can then be cut down until a good foundation is obtained, and then rebuilt as high as the roof, the roof bricks being then replaced. Another portion of the roof can now be removed and a further portion of wall repaired, until the whole is finished, including probably the door arch. In this way almost the whole of a side wall can be replaced in from two to three hours, while the furnace is still red-hot.

Most electric furnaces up to 15 tons capacity are fitted with removable roofs, which are fixed independently of the side walls. This makes the matter of roof repairs a very simple operation, merely consisting of exchanging an old roof for a new one; but some works find it inconvenient, owing to lack of crane power or other causes, to keep spare roofs. But knocking the old roof in, cleaning out the refuse, and then rebuilding a new roof on the old casing, is always a much longer job, for whereas a spare roof can be placed in position in less than an hour, to remove an old roof and rebuild a new one on the furnace cannot be done in less than five or six hours, with consequent considerable loss of heat during the operation.

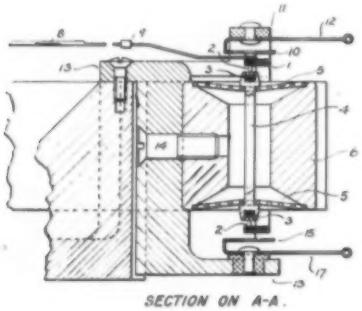
As it is so easy to carry out repairs with very little delay to the furnace, it is bad practice to carry on with thin walls and roofs, as the abnormal radiation of heat that takes place entails a much greater consumption of electrical energy. A short stoppage for repairs will always more than repay the cost by subsequent economy of current.

Modern Pyrometer Work in Iron and Steel Industries.

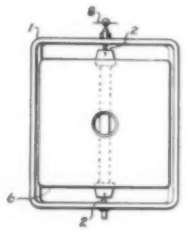
A Notable Design of Thermo-Electric Moving Coil.

(Contributed.)

PRACTICALLY every article in common use to-day has involved the use of accurate temperature control at some stage of the manufacture, and great advances have taken place during recent years in the design and construction of pyrometers. The matter is of outstanding interest to the iron and steel industries, including the operation of blast furnaces, steam and power plant, and the efficient utilisation of waste heat. Mostly, of course, except for very low temperatures, say, under 200° F., and conditions over, say, 2,900° F., the "distance" electrical or the thermo-electric principle is employed. The latter is particularly important, involving, for example, no "external" source of electricity, and the principle, it will be remembered, depends on the fact that when a junction of dissimilar metals, forming part of a circuit, is heated an extremely small current flows round the entire circuit, proportional to the degree of heating—that is, the temperature. Essentially, therefore, a thermo-electric pyrometer consists of a resistant tube containing a junction of dissimilar metals placed in the heated area, connected by two flexible wires to a millivolt meter, to indicate or record the current flowing in the circuit, but graduated so as to read the temperature direct. Typical dissimilar metals used are platinum and platinum-rhodium alloy, iron and copper-nickel alloy, and nickel and nickel-chromium alloy. Also the millivolt meter has a tiny moving coil of wire, carrying a long pointer, balanced on pivots between the poles of a permanent magnet. When the thermocouple tube is placed in the source of heat an electric current, as stated, flows through the circuit, including the moving coil, which thereby develops a magnetic field, and is affected by the permanent magnet, so that the coil turns on the pivots, moving the pointer over the scale and indicating the exact temperature.

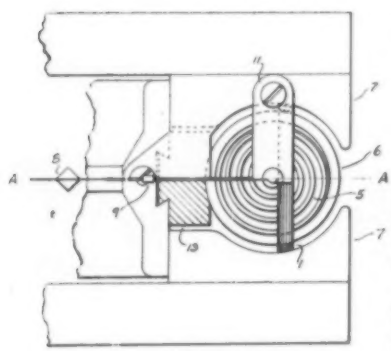


SECTION ON A-A.



ELEVATION OF COIL & CORE UNIT.

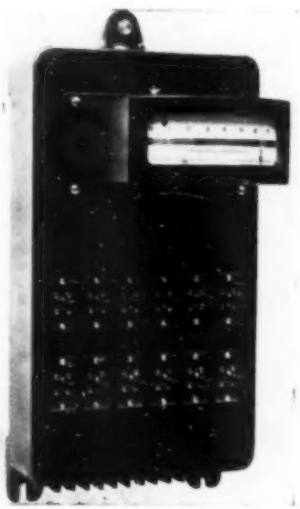
Detailed drawing of the "Resilia" coil-mounting for pyrometers, of the Foster Instrument Co., Letchworth.



PART SECTIONAL PLAN.

One of the most important items in an efficient thermo-electric pyrometer is this moving-coil, which must be strong enough to stand the reasonably rough usage of industrial conditions, whilst also being extremely sensitive and accurate. Great interest attaches in this connection to the latest "Resilia" moving coil design of the Foster Instrument Co., of Letchworth, which on the most ingenious lines, evolved as the result of extensive practical experience, has attained the ideal of strength and robustness, combined with the accuracy of a laboratory research instrument. Essentially, the conical pivots carrying the moving coil with attached pointer, working as usual in recessed jewel bearings, have the jewels at the top and bottom connected by a tiny rod, which is also mounted in a powerful spring. As a result it is impossible for the pivots to "jump" in the jewel bearings—that is, become slightly separated by shock or vibration, causing the wear and tear and loss of accuracy characteristic of many types of pyrometers.

The design is illustrated herewith, being a part sectional plan, with above a vertical section on the line A–A, while on the right is an elevation of the coil and core unit. Between the pole pieces of the magnet (7) and the cylindrical iron core (6), a magnetic field is established, while (1) is the coil, with the light pointer (8), through which passes the current from the thermo-couple, turning about the light vertical rod or axis (4) in the space between (6) and (7). At the top and bottom the coil has inturned pivots (2) working in conical jewel bearings (3), mounted on the rod (4), held in position at both ends relative to the core (6) by light springs (5) cut out of a thin flexible metal plate. As a result of this special arrangement, a jolt or undue vibration means that the whole system of coil, pivots, jewels, and rod must move together, and it is impossible for the pivots to separate and strike the jewels. The current from the thermo-couple passes down through the moving coil by way of a frame control spring (16), ligament (15), and insulated arm (17), while the arm (12) acts as the zero adjuster. Also, it is interesting to note that the moving coil is mounted slightly eccentric to the axis (4), so that its weight balances the weight of the pointer (8), with final very accurate adjustment of the balance by a tiny sliding weight (9), eliminating the use of a counter-weight and tail. Further, the core (6) is held by the screw (14) to a rigid frame (13) attached to the magnet, the whole arrangement being extremely sensitive and light in weight, in spite of being highly resistant to shock. Also, in connection with "Foster" thermo-electric pyrometers, it may be mentioned complete magnetic shielding is provided, while the "Resilia" movement is, of course, equally applicable to the firm's electric "distance" pyrometers, as well as voltmeters and ammeters and other instruments.



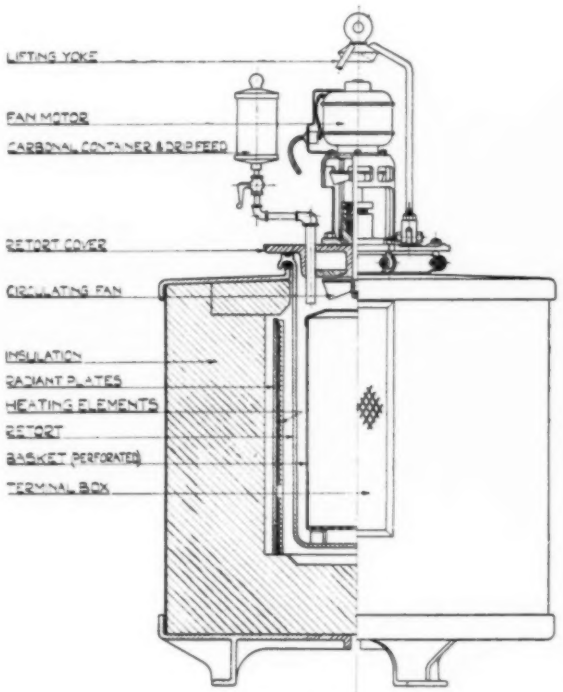
Foster Wall-type Edgewise Indicator, with Sunk Type Switchboard for 24 Connections, and "Resilia" Mounting

To some considerable extent there still exists a prejudice in the iron and steel industries against pyrometers, which is a relic of the days when the indicating and recording devices were too fragile for commercial use. However, such fears no longer apply and, it may be stated, "Foster" indicating and recording instruments are now operating with great success on the boiler plant of the new Canadian Pacific liner *Empress of Britain*, a severe test, because of the peculiar vibration of turbine ships, with small amplitude and high periodicity. Also, the firm have interesting designs of optical and radiation pyrometers for taking the temperatures, for example, of molten metal, heated billets, molten slag, and the interior of furnaces, much over 2,500° F., the average melting point of the platinum group of metals being about 3,090° F., constituting the most resistant materials available for the thermocouple.

Recent Developments in Tools and Equipment

A NEW METHOD OF CASEHARDENING.

A NEW method of carburising has recently been introduced for which a liquid carburising agent, known as "Carbonal," has been patented. It is used in conjunction with an improved type of furnace, in which the charge to be treated is loaded in a basket, as shown in the diagrammatical illustration Fig. 1. No special attempt is made to keep the components of the charge from touching each other; they should, however, be so placed as to allow the circulation of the carburising medium to take place throughout the charge. In this way maximum uniformity in penetration and structure is obtained. The loaded basket sits inside a heat-resisting alloy retort inside the furnace chamber as indicated. In place of a basket, plates suspended on a vertical rod can be used for bevel and other gears, and camshafts can be suspended inside the retort.



Carbonal Furnace.

The retort is fitted with a special cover, which makes a sealed working chamber. A motor-operated patent paddle fan incorporated in the cover, and shown in the illustration, circulates the carburising gases throughout the charge.

The furnace and charge are brought up to heat with the fan running, which gives a rapid and uniform rise to the carburising temperature of about 940° C., this temperature depending upon the type of steel used and the kind of case structure required. The Carbonal is then introduced into the hot retort by means of a drip-feed attachment mounted on the retort cover.

The Carbonal, which is made up of a vegetable base, very rich in hydrocarbons, on entering the retort, is forced outward against the hot walls by the centrifugal action of the circulating fan, where it is immediately cracked up into hydrocarbon gases, which circulate through the charge, thus exposing it to a very active carburising agent. The forced circulation assures fresh uniform gas being brought to the work continuously.

Carburising proceeds very rapidly. A penetration of *from* 12 *to* 15 *thousandths of an inch at* 930° *C. takes place per hour.* After the carburising cycle is complete, the retort is lifted out of the furnace by an overhead gear, and cooled in the air, while a second loaded retort is placed in the furnace. In some cases the carburised work is quenched from or a little under the carburising temperature, this being accomplished by removing the cover and handling the charge direct to the quench, by means of the basket containing the charge.

The following production costs, which are of interest, are based on a typical furnace corresponding to those shown in Fig. 2, and having an inner basket dimension of 18 in. diameter by 42 in. deep, accommodating a charge of work weighing 1,000 lb.

Current Consumption.—A furnace of the above size has a fixed input of 75 kw. With this input it is claimed to be possible to bring the total gross charge up to carburising temperature *in three hours.* During this period approxi-

Four Electric Vertical Carburising Furnaces using "Carbonal," a liquid carburising agent.

mately from 200 to 225 kw.h. would be consumed. The amount of consumption is less than the full input of the furnace at three hours because the chamber will come up to temperature more rapidly than the centre of the charge, which means that the furnace will go on control before the charge is saturated. Three hours, however, would be a fair estimated time for this.

Radiation losses will be 15 *kw.* at carburising temperature. For a case depth of $\frac{1}{16}$ *in.* the normal carburising time is *four hours*, resulting in power consumption of 60 *kw.h.* The total current consumption for the whole cycle (lasting seven hours) would be approximately 285-300 kw.h., or a production rate of 3.33 lb. per kw.h.

Where it is possible, a lower production cost can be obtained by loading a spare retort into the hot furnace, and still further reduction can be made if the work can be quenched from the basket, and the already hot retort loaded and replaced without losing much of its heat. Under these conditions weights as high as 5·5·6 *lb.* per kw.h. can be obtained.

For case depths of $\frac{1}{8}$ in. and $\frac{3}{16}$ in. the respective carburising times are 8 and 15 hours.

Consumption of Carbonal for the foregoing operation is about 1 pt. per hour, and the cost of Carbonal is about 8½d. per pint.

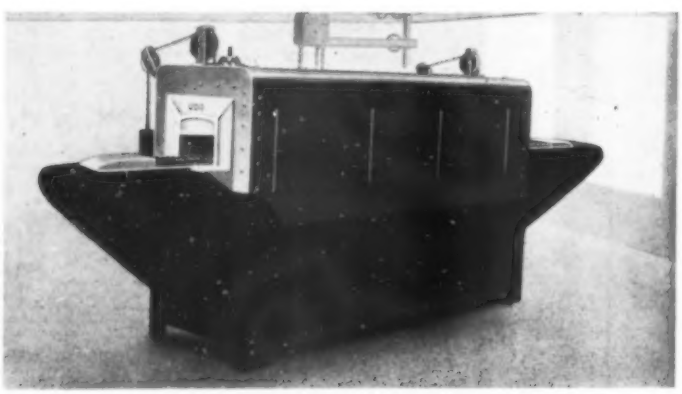
Summary of Costs.—Total cost of carburising per nett pound of components, including cost of current, Carbonal, and amortisation of retort and basket, based on a $\frac{1}{16}$ in. of case and an average load of 1,000 lb. per charge :—

With Current at—	Cost per Nett Lb. of Components.
¼d. per unit	0·186d.
⅜d. ,,	0·223d.
½d. ,,	0·281d.
⅝d. ,,	0·298d.
¾d. ,,	0·336d.
⅞d. ,,	0·373d.
1d. ,,	0·411d.
1¼d. ,,	0·448d.
1½d. ,,	0·486d.
1¾d. ,,	0·523d.
1¾d. ,,	0·561d.

This new method of carburising has been introduced by the Hevi Duty Electric Co., whose European Patent Rights are controlled by Wild-Barfield Electric Furnaces, Ltd., and G.W.B. Electric Furnaces, Ltd., respectively.

ELECTRIC CONVEYER FURNACE.

THE principal uses of the conveyer type of furnace is the hardening, tempering, or annealing of repetition work. As the time of heating in the furnace is a definite unit for any one rate, it is necessary that the articles to be treated should be alike, or, at any rate, about equal in section and weight, otherwise the time which would be suitable for one article would not be suitable for another of twice or half its weight. However, in these days of mass production, the conveyer type of furnace fills a long-felt want, and the hardening of such articles as gudgeon pins, gears, etc., or the normalising of forgings is economically carried out by such a continuous process.



Electric Conveyer Furnace.

A recent development of this kind is the continuous furnace by Kasenit, Ltd., shown in the accompanying illustration, which is a development of this firm's tool-hardening electric furnace. The length of the chamber can be made to any reasonable size, with the temperature regulated to a uniform heat throughout the entire length of the chamber, or a series of temperatures to suit local conditions. The conveyor chain is made from the best-quality chromium-alloy steel, and will stand up to a temperature of 1,000° C. for long periods. The chain is driven by a 1-h.p. motor through a three-speed gear-box, so that the operator can control the time of the parts to be heat-treated without any time being wasted.

The heating elements used in connection with the construction of this furnace are of the silit-rod type. This non-metallic resistance material was developed to comply with the need for a commercial material capable of maintaining a similar resistance, against the influence of atmospheric air under high temperatures, as previous metals.

The silit rod is obtained by thoroughly mixing silicon carbide, silicon, and carbon together, pressing these into forms, and then exposing them to the action of carbon monoxide at a heat of about 1,500°. This combines all the valuable attributes which an electric heating body must have, namely, high fireproof qualities, great resistance to the influence of the atmospheric air, and high variable specific resistance. Silit rods are made in different classes for various purposes, but for the electric furnace they are produced as an electric resistance material for permanent loads under glowing temperature and for high momentary loads, or as electric heating resistances for temperatures up to about 1,400° C.

The heating elements have a long life at temperatures up to 1,000° C. They are easily replaced without any alteration to the existing brickwork, and in case of an element breaking whilst furnace is at work (a very rare occurrence), the series of elements with which the broken one is connected can be switched off and a new silit rod fitted in a few minutes.

The furnace is a complete unit and does not need any special foundations. It can be placed anywhere and its position changed according to the requirements of manufacture. Efficiency in this type of furnace is very high, as no flue outlets and combustion chambers are required. The consumption of current is that necessary to compensate the loss of heat by radiation. The atmosphere round the furnace is just above normal temperature ; consequently, those working in the vicinity, and particularly the operators, have excellent hygienic conditions, which ensure maximum quality of work.

It is not possible, in a short article such as this, to give details concerning consumption of electricity per pound of metal treated, as the temperature and rate of working depend not only on the size of the pieces, but on the temperature of working ; but Messrs. Kasenit, Ltd., will be glad to give these particulars on request if details of each requirement are supplied.

BRITISH CHEMICAL STANDARD HIGH DUTY IRON " G."

We are informed that a new high-duty iron is now about to be issued. The analysis is as follows :—

	Per cent.
Total Carbon	2.68
Graphite	1.82
Combined carbon	0.86
Silicon	1.30
Manganese	0.410
Sulphur	0.125
Phosphorus	0.45

This sample has been made specially to meet the need for an iron low in total carbon, moderately low in phosphorus and fairly high in sulphur content. Great care has been taken to prepare fine turnings free from dust, as so to make it as homogeneous as possible, and particularly with a view to its use for the determination of total carbon and graphite. It is of interest to note that in order to prevent deterioration, the bulk of the turnings are being stored in an atmosphere of dry nitrogen.

By using British Chemical Standard irons " A," " B " " G " and " D 2," either separately or in conjunction, it is now possible to have standards which cover all the usual requirements of ordinary cast iron. In accordance with the usual practice, iron " G " has been standardised by a number of chemists, representing manufacturers of refined iron, makers and users of high-duty castings, also independent analysis.

Unusually full notes on the methods of analysis used are given on the certificate of analyses issued with each bottle. Further particulars may be obtained from British Chemical Standard Headquarters, 3, Wilson Street, Middlesbrough.

Business Notes and News

Production of Coking Coals.

A discovery of considerable interest is disclosed in the report on "The Action of Hydrogen upon Coal," recently published by the Department of Scientific and Industrial Research. It appears that chemists of the Fuel Research Board, while conducting experiments on the Bergius process of obtaining oil from coal, found out, by accident, that it was possible to make non-coking coal into good coking coal by treating it with hydrogen at a proper temperature and pressure, beginning with pressure of 100 kilograms per square centimetre, and working up to a maximum of 250, with a maximum temperature of 340° C. Though the discovery is not now of commercial value to British industry, as there is ample coking coal available in Britain, it should be of great value to those British Dominions which possess little or no good coking coals for smelting purposes.

To Advertise British Goods.

The British Exhibitor, a liner which is designed to advertise British goods at over 30 ports in different parts of the world, is to sail from London in November, on its first trip. The purpose of this venture, as pointed out by Lord Auckland, managing director of the company organising the trip, is to provide British manufacturers with a means of exhibiting their wares before potential customers in certain of the most valuable markets of the world, and to exhibit them in a way which will appeal to the imagination of those customers. The manufacturers have seen the value of this project, and already options have been taken on more than half the available exhibition space. The vessel's first cruise will be to the West Indies and South America. It will visit in turn Bermuda, Jamaica, Trinidad, Cuba, ports on the West Coast of North America and Central America, and every port of consequence in South America.

Rustless Iron Development.

An interesting development was inaugurated recently when the newly erected works at Darlington of the Darlington Rustless Iron and Steel Co., Ltd., were put into operation. A satisfactory trial run of the equipment was witnessed by Mr. A. H. Wild, president of the International Rustless Iron Corporation, whose brother is the inventor of the process, and Signor Tagliaferi, an Italian engineer, who is responsible for the method of furnace control which is an important feature of the process.

Floating Dock for Wellington Harbour.

The three sections of the Wellington Harbour Jubilee Dock recently launched at the Wallsend shipyard of Messrs. Swan, Hunter, and Wigham Richardsons, Ltd., have been built for the Wellington Harbour Board, New Zealand, who purpose carrying out extensive improvements to their harbour, which is one of the finest in New Zealand.

The Jubilee floating dock is double sided, self-docking, and of the sectional box type. It is divided into seven sections. It has an over-all length of 584 ft. with an outside width of 117½ ft. The lifting capacity of the dock is 17,000 tons and it can be sunk to a depth of 26 ft. over the keel blocks.

There are four vertical spindle centrifugal pumps, driven electrically and of sufficient power to lift a vessel of 10,000 tons displacement with a draft of 26 ft. on to the dock within two hours. On the starboard side about midships, is the valve house, from which the working of the dock will be controlled by means of levers worked electro-pneumatically.

The mechanical side shores and the bilge blocks are all worked from the wall deck. At each of the four corners of the dock is placed on the walls an electrically driven warping capstan for manœuvring vessels in and out of the dock.

The War Against Rust.

In a recent broadcast talk on "The War Against Rust," Dr. W. H. Hatfield described the strange qualities of stainless steel. The rust-resisting qualities of chromium steels, he said, were probably due to the formation of a protecting film on the surface directly it came in contact with the atmosphere. Even if the steel were scratched this film was spontaneously formed and the steel did not suffer. Many people think that stainless knives may not be sharpened, but, as Dr. Hatfield observed, "all knives should be sharpened, and sharpening in no way affects the stainless quality of the steel."

Cruisers Crippled by Defective Castings.

The reported crippling of five of America's new cruisers, as a result of cracks which have developed in the stern frame castings is regrettable. These castings are of steel, and, as is well known, are attached to the keel plate and form a support for the stern plates as well as the rudder. Many types of castings are more complicated in design, but there are few that have as much variation in thickness of metal as steel castings used for ship construction. It is this difference in sectional thickness that causes difficulties in the production of sound castings, although other factors have an important influence. The shrinkage of steel is high, and, when the thickness of metal varies, the rate of cooling, after casting, is irregular and the metal contracts irregularly and becomes strained.

The amount of shrinkage in a casting will, of course, depend on the carbon content of the steel used as well as the temperature of the metal when cast. The lower the carbon content and the hotter the metal the greater will be the amount of shrinkage. In many cases this is so great that a casting may crack while the metal is solidifying, but, in every case, a casting of this type is always in a condition of severe internal stress when lifted from its mould, and extreme care must be exercised in handling it until it has been annealed.

Low-carbon steels are soft and may be sufficiently tough to prevent rupture under contraction stress, but castings from high-carbon steels are more brittle and give considerable trouble. The object of annealing these steel castings is to relieve internal stresses and so make them more reliable under working conditions.

It is rather remarkable that five vessels of a similar type should suffer in exactly the same way, and while an investigation will undoubtedly be made in order to determine the cause, the defects may be due to faulty design. Certainly it appears to be a strange coincidence if the responsibility rests entirely with the foundries where the castings were made.

Fenton Blast Furnaces Cease Work.

Severe competition is having a serious effect in the production of pig iron in this country. The gradual fall in prices which has taken place during the last eighteen months has rendered it economically impossible to operate the blast furnaces of the Stafford Coal and Iron Company's undertaking at Great Fenton, Stoke-on-Trent. The steadily falling prices of pig iron have already caused the Company to sustain heavy losses and the directors have reluctantly been compelled to close down the blast-furnace plant.

New Plant for Centrifugal Casting.

The new plant of the Staveley Coal and Iron Co. for the manufacture of sand-spun cast-iron pipes by centrifugal casting, can turn out straight pipes at the rate of one every minute and a half. Production of these pipes on a large scale has been started at the Staveley Works, near Chesterfield. It is claimed that these pipes, being made in 16-ft. lengths, and containing about the same amount of iron as the ordinary 12-ft. pipe, have fewer joints and are, therefore, easier to transport and handle. The centrifugal action gives them increased toughness, elasticity, and resistance to shock. British materials are used throughout, the ore, which comes from the company's own mines, being smelted at the adjoining Devonshire Works, while the coke used is made from coal from collieries also owned by the company.

Developments at the National Physical Laboratory.

Many new developments of unusual interest were exhibited recently when the National Physical Laboratory at Teddington was open to visitors, and the new physics building was formally opened. This new building, of which only part is finished, is to have the Heat and General Physics Section of the Physics Department, with part of the radiology and sound work. Apparatus for the measurement of noises was on view in the building and the testing processes were fully explained.

Other demonstrations which aroused special interest were tests of aeroplane models in giant "wind tunnels," and tests carried out with a model ship in the large tank of the William Froude Laboratory, while in other departments there were peak-voltage tests, wind-pressure tests, and tests of "creep" rates in metals. The opening ceremony was performed by Sir Gowland Hopkins, President of the Royal Society and Chairman of the General Board of the National Physical Laboratory, who used a gold key presented to him by the architect, Mr. F. A. Llewelyn.

Some Contracts.

The Electric Furnace Co., Ltd., of 17, Victoria Street, London, S.W., report a contract received from a well-known Continental steelworks for a high-frequency furnace installation which will be the largest unit hitherto constructed. The motor-generator set will have a power input of 1,375 kw., and the furnace will be capable of melting 4-ton charges. Provision will also be made for a furnace body of 7 tons for the treatment of molten metal. This installation will represent an important advance in the technique of high-frequency furnaces, and the treatment of metal in larger quantities will overcome much of the expense and inconvenience experienced with the small charges that have been used in the past.

One of the largest contracts for mechanical boiler draught and flue-dust collector equipment that has ever been placed in the British Isles, has been awarded to Messrs. Davidson & Co., Ltd., Sirocco Engineering Works, Belfast, by the Newcastle-on-Tyne Electric Supply Co., Ltd. The equipment is for the new power station at Dunston-on-Tyne and in value amounts to over £100,000.

Messrs. Vickers-Armstrongs, Ltd., Barrow, have recently received an order from the Admiralty for a submarine, to be named "Porpoise." Vickers-Armstrongs are at present building another super-submarine, two destroyers, and a P. and O. steamer.

Sir Robert Ropner & Co., Ltd., have ordered from Messrs. William Gray & Co., West Hartlepool, a steamer of 9,000 tons deadweight. Destined for the St. Lawrence coal and ore trade, the vessel will be of a special type, having extra hatches and open holds.

One of the largest contracts for constructional steel placed in the Manchester district in recent years has been secured by Edward Wood & Co., Ltd., Ocean Ironworks, Trafford Park, Manchester. It is for the steel framework for the new store of Messrs. Lewis's, Ltd., at Leeds, and is valued at £60,000. More than 4,000 tons of steel stanchions, beams, and girders will be used for the building.

The Portuguese Ministry of Marine has signed a contract with the British firms of Vickers Armstrong, Thornycroft, and Hawthorn Leslie for the building of two new naval dispatch boats at a cost of £155,598.

Lobnitz & Co., Renfrew, have received an order from the Karachi Port Trust for a tug, and from the Bombay Port Trust for a steam anchor hoy and fire float.

John Adam & Co., Ltd., Glasgow, have secured a contract from the Aberdeen Harbour Commissioners for the reconstruction of the western portion of the Albert Quay at Aberdeen Harbour. The contract, which provides for the reconstruction of 990 ft. of quay and other works, is valued at £38,221.

Walthamstow Corporation have placed an order with the Brush Electrical Engineering Co., Ltd., Loughborough, for eight double-deck covered-top tramcar bodies and eight pairs of maximum traction trucks.

Two "Avro 10" three-engined monoplanes, with accommodation for eight passengers and two pilots, have recently been supplied to Imperial Airways, Ltd., by A. V. Roe & Co. Ltd., Newton Heath, Manchester. The machines are fitted with 215 h.p. Armstrong Siddeley "Lynx" engines, and have a maximum speed of 115 m.p.h. and a cruising speed of 100 m.p.h.

Simon-Carves, Ltd., Cheadle Heath, near Stockport, have secured contracts for the erection of British "Baum" coal washeries for Messrs. Bestwood Coal and Iron Co., Ltd., and for the Cowpen Coal Co., Ltd., Newcastle-on-Tyne. The capacities of these washeries will be 100 tons and 160 tons, respectively. Another order has been secured from Messrs. Wath Main Colliery Co., Ltd., to extend their "Baum" washery capacity from 75 to 150 tons per hour. Other orders received recently include those for the extension of the washery of the Manvers Main Collieries, Ltd., and for a slurry plant for the "Baum" washery of Messrs. Emlyn Anthracite Colliery, Ltd., Swansea.

The Pulsometer Engineering Co., Ltd., Nine Elms Iron Works, Reading, have received an order for the supply and erection of pumping plant for the City of Chester Sewage Works. The equipment comprises three 15-in. and three 12-in. centrifugal pumps, which, when operating together, will deliver 28,000 gallons per minute of screened sewage against a head of 50 ft.

The Portuguese Government have placed an order with Messrs. Yarrow & Co., Ltd., Scotstoun, Glasgow, for four torpedo-boat destroyers, each 322 ft. in length and having a guaranteed speed of 36 knots. They will be driven by turbines working in conjunction with Yarrow water-tube boilers equipped with Yarrow superheaters and air heaters. Two of the ships are to be completed at Scotstoun, while the other two will be built at Lisbon under the supervision of Messrs. Yarrow.

The Post Office has placed a further order with Messrs. Siemens Brothers & Co., Ltd., Woolwich, London, S.E. 18, for 200,000 "Neophone" microtelephone instruments.

Charles Roberts & Co., Ltd., Horbury Junction, Wakefield, have secured a contract from the Egyptian State Railways Administration for ten 10-ton benzine tank wagons to be delivered at Gabbary, Alexandria.

The following recent orders have been received by the Associated Equipment Co., Ltd., Southall, Middlesex:—Four "Regal" 32-seater, single-deck omnibuses, Burnley Corporation; two "Regal" 32-seater, single-deck omnibuses, Pyburn Garage and Transport Co., Ltd.; six "Regent" double-deck omnibuses, Tynemouth and District Electric Traction Co., Ltd.; three "Mercury" 3½-ton freight vehicles, Shell-Mex, Ltd.

Crossley Motors, Ltd., Manchester, have received an order from Bury Corporation for five complete heavy-oil-engine double-deck omnibuses.

Birmingham Corporation have placed an order with the General Electric Co., Ltd., Witton Works, Birmingham, for eleven trolley buses, the chassis for which will be supplied by Leyland Motors, Ltd., Leyland, Lancashire. They have also decided to purchase ten "Dictator" 34-seater single-deck buses from Morris Commercial Cars, Ltd., Soho, Birmingham.

The Great Western Railway Co. has ordered 20 electric motors from Crompton Parkinson, Ltd., Guiseley, near Leeds. These are to be installed at their Cathay Works, Cardiff.

John I. Thornycroft & Co., Ltd. Basingstoke, Hants, have received orders for 3-ton six-wheeled vehicles from the Belfast Co-operative Society, and from Boots' Pure Drug Co. Repeat orders have also been placed by the Metropolitan Railway, the Talbot Serpell Transport Co., Ltd., and Venture, Ltd.

Swan, Hunter and Wigham Richardson have secured a contract for the building of a new ship at their Tyne yard at Wallsend.

Harland and Wolff have received an order from the Wallasey Council for the construction of a new ferry steamer of 350 tons. The contract, which will be carried out at Govan, Glasgow, is valued at £43,290.

The London Underground Electric Railways Company, London, have placed a contract with Mitchell Brothers, Sons & Co., Ltd., Victoria Street, S.W. 1, for work in connection with the installation of escalators and the construction of a new booking-hall at Knightsbridge Station on the Piccadilly railway.

The North British Locomotive Co., Ltd., of Glasgow, have received from the Crown Agents for the Colonies a contract for five 4-6-0 engines, each with an eight-wheeled tender, for service on the Gold Coast Government Railways.

The Buenos Ayres and Pacific Railway Co., Ltd., have awarded a contract for six locomotive boilers to Robert Stephenson & Co., Ltd., of Darlington, and one for two locomotive boilers to Beyer, Peacock & Co., Ltd., of Manchester.

Some Recent Inventions.

SHAPING AND CLEANING INGOTS.

THE enormous increase in mass production of ordinary steels has led to a corresponding demand for high-grade steels. With increasing production methods have become more exacting in order to meet the increasing specifications and tests now required for all kinds of alloy steels. Formerly these special steels were produced in small quantities in crucibles, and small ingots of approximately 3 in. to 5 in. in diameter sufficed, and it was of little importance whether these small ingots were round or square. To-day, however, greater quantities of cheaper high-grade steel are now necessary, and the size of ingots has increased, bringing into prominence the question of shape of ingots used in manufacture.

With the increase in size of ingots it was recognised that finished products from angular ingots produced less waste and better material, and, consequently, practically all large steelworks now adhere to the square ingot for all weights. This problem was uniformly solved in the mass

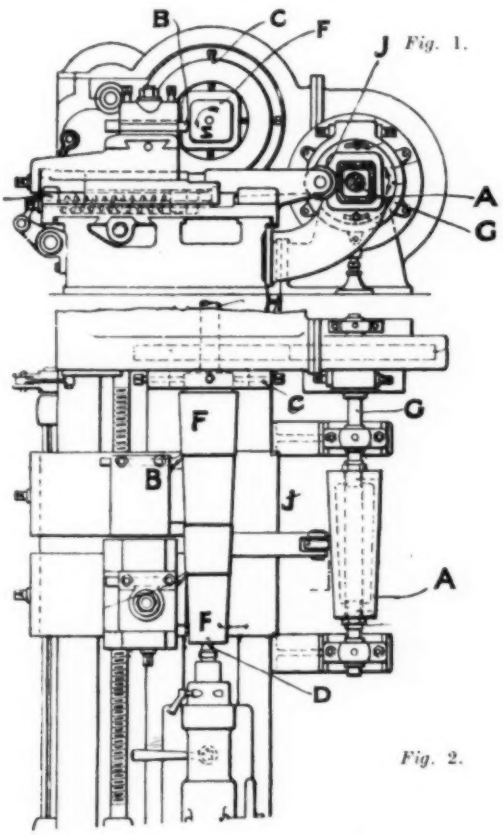


Fig. 1.

Fig. 2.

production of ordinary steel in which all steelworks used heavy square ingots, but technical considerations necessitated some deviation. With ordinary steel the ingots are used in their original state, having their casting skin exactly as it was immediately after drawing. The casting skin on high-grade ingots, however, gave rise to inferior finished products, and the greater the number of working stages the worse was the result.

To get the best results from square ingots of high-grade steel it has been proved that it was necessary to remove the usual defects from these ingots. The removal of the casting skin and other more deeply rooted surface cracks was essential, and the machining was required to be done cheaply and effectively. This problem has been solved by a square-turning lathe, which has proved an important economic factor in many works producing alloy steels.

The machining of the ingot is effected by means of an ordinary cutting tool, but in operation the circumferential speed of the ingot changes according to the lateral surfaces or corners, and in consequence the cross-slide with the cutting tool has a reciprocating trajectory. The movement of the cross-slide is controlled by a former, so that the correct shape of the ingot can be defined. A vertical section of a form of apparatus designed for carrying out this operation is shown in Fig. 1, while a plan view, exclusive of the usual main drive, is shown in Fig. 2.

In the construction illustrated, A is the former, B the turning tool, which is controlled positively by the former, and C, D are means for gripping the ingot F. The former is mounted on a shaft G, which is driven by the shaft H by means of gears. The shaft H is connected to a main driving motor, so that the ingot F is rotated towards the cutting edge of the tool B. The tool is mounted in a support forming part of a slide rest.

The former B operates by one or more rollers J supported on a carriage which is mounted to slide upon a base-plate. The base-plate is arranged so that it slides on the machine bed. On the supporting carriage springs operate in such a way that they continually press the roller against the former and the tool against the ingot, giving a transverse movement.

In this device the former has the advantage of being shorter than the work, as it not only gives lightness but enables a number of tools to be used at different points. In the construction shown in Figs. 1 and 2 the former may be moved in the direction of the axis of its shaft, and, in addition, by means of a drive, it may be adjusted to rotate, the former shaft being coupled to a disc which is provided with slots through which pass bolts.

In operation power drives the shaft H and also shaft G, and the ingot and former are rotated at the same speed, and run synchronously. The roller J, which is pressed against the periphery of the former, is moved to and fro by the rotation of the former, and this results in the tool, or tools, making a to-and-fro movement and turning the ingot to the required shape. When treating the first ingot, the position and shape of the former with regard to the ingot can be changed and adjusted, until the former has a position and shape which guarantees the production of clean, faultless intermediate products with a minimum of waste material. After the former has once been adjusted for a given series of ingots the operation can proceed practically automatically. The machine provides facilities for independent adjustment of the tool, so that local adjustment off the cut can be made from time to time as required. The machine with these improvements is claimed to provide the more modern method of freeing the ingot from surface cracks and blemishes quicker and more economically than any other method previously devised.

348,157. Messrs. H. A. WALDRICH, of Siegen, Germany, and PETER EVERMANN, of Hohlweggasse, 26, Vienna, Austria, patentees. Messrs. Reddie and Grose, Agents, 6, Bream's Buildings, London, E.C. 4. Accepted May 5, 1931.

SULPHUR-RESISTING ALLOYS.

A SERIES of alloys having as important constituents iron, nickel, and chromium, are recognised as having a chemical resistance against the influence of certain chemical agents, or as resistants to oxidation at high temperatures. Generally they satisfy the requirements laid down with regard to resistance to oxidation. At the present time there is a need for alloys which are also sufficiently resistant against a sulphur-containing atmosphere in which the sulphur is contained either in the elementary form or as a compound, particularly as a reduced or reducing compound. As a result of recent investigations the resistance to sulphur of such high-melting metals and alloys is increased by adding aluminium in appreciable quantities, preferably at least 9%.

Investigations have been carried out with various metals and alloys containing varying percentages of aluminium

with the object of showing the increases of weight which occur on annealing in a sulphuretted-hydrogen atmosphere. The results of tests show that an increase of aluminium content increases the resistibility of the metals or alloys to hydrogen sulphide and particularly good resistibility is obtained with an aluminium content of about 10% upwards.

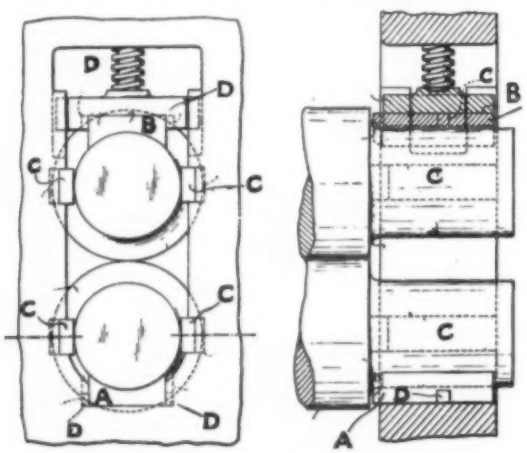
The investigations have been made with nickel containing different aluminium contents at 700°, 800°, 900°, and 1,000° C.; an alloy of 61% nickel, 15% chromium, 20% iron, 4% manganese, with different percentages of aluminium at similar temperatures; iron with increasing aluminium contents at 700° and 800° C.; and cobalt with increasing contents of aluminium at 700°, 800°, 900° and 1,000° C.

The possibilities for the use of these sulphur-resisting alloys is very considerable, particularly in connection with the constructional material for recuperators, annealing and hardening chambers, constructional elements for roasting furnaces, and other interior parts of furnaces.

342,868. HERAEUS VACUUMSCHMELZE AKTIENGESELLSCHAFT, and WILHELM ROHN, of Hanau am Main Germany, patentees. Messrs. Gill, Jennings and Everyclaytcn, agents, Chancery Lane, London, W.C. 2. Accepted: February 12, 1931.

ROLLING MILL BEARINGS.

MANY improvements have been made in bearing design with the object of increasing the speed of rolling. So heavily are the bearings loaded that experiments have shown as much as 60% of the power consumed in a mill is used to overcome friction at the roll necks. Increasing the speed of a mill with reasonably heavy reductions, in addition to imposing heavy strains upon the roll necks, heats the bearings to such an extent that inaccuracies in thickness of rolled material result, and the power consumed is excessive. Improvements in bearings have met with



Bearings for Rolling Mills.

varying degrees of success; roller bearings, for instance, have shown good results on hot mills and light-type cold mills, where the loads are relatively low, but with heavy cold mills they have not been entirely successful. This is due to the reduction of the roll necks necessary to fit roller bearings. In heavy rolling the strain imposed upon the necks is such that they must be as large as the roll will reasonably allow.

A recent improvement in bearing design for rolls dealing with sheet, tin-plate, as well as other mills, has for its object the distribution of stresses imposed in rolling to prevent parts becoming unduly heated by friction, and so maintain the necks of the rolls in a relatively cool condition. The bearing comprises top and bottom brasses, which are held in suitable seats in the roll housing. The brasses have lugs to prevent endwise movement, which are spaced at their inner ends from the rolls, with side liners fitted for limiting the lengthwise movement of the rolls. The bearing for the necks is composed of a number of isolated parts over which the high stresses are distributed. A further object in this design is to provide a bearing in which the horizontal pressures are supported by parts other than those bearing the vertical pressures. The parts subject to the latter pressures are concerned wholly with rolling stresses, and are not in contact with the fillets of the roll necks. It is claimed that this prevents overheating, due to a reduction in frictional heat, which reduces the loss through cracking and breakage of rolls, and also the amount of lubricant necessary; further, it increases production of a mill due to absence of delays, and produces plates and sheets of more uniform gauge.

The accompanying illustrations show the arrangement of the bearings. It will be noted that the lower roll rests upon the bottom bearing brass A, the top brass B fitting on the neck of the upper side, with side brasses or lines C located at opposite sides of each roll. The bottom brass is rectangular in shape, and is firmly seated in a recess in the mill housing. It carries lugs at D which fit in corresponding pockets in the housing to prevent longitudinal movement. The top brass, which fits in a recess in a cover, is similar in form to the bottom brass. Lengthwise movement of the rolls is prevented by the side liners, which are also seated in recesses in the roll housing.

The top and bottom bearings are so arranged that at no time do they come into contact with the roll fillets, and therefore do not directly impart to the fillets the heat resulting from such pressures. The end thrust pressures are received by the lugs which have only line contact with the roll necks and end contacts with the flat portions of the roll ends; thus they are not liable to become heated to high temperatures and cannot impart much heat to the fillets.

347,995. THE PHOSPHOR BRONZE CO., LTD., and Z. PAYNE, both of Sumner Street, London, S.E. 1, patentees. Messrs. Dicker, Pollak and Mercer, Agents, 20-23, Holborn, London, E.C. 1. Accepted May 7, 1931.

Aluminium in Architecture.

Aluminium as a feature of internal decoration has been used for a long time, but only on a small scale; and it is only within very recent years that it has been utilised to any great extent for architectural purposes, both internal and external. The possibilities of this application are very well set out in a brochure recently issued by the British Aluminium Co., Ltd. This publication, which is a work of art in itself, contains a short introduction dealing with the architectural values of the metal, together with some two dozen interesting illustrations. It is a significant feature that many of these illustrations are of buildings in Canada and America. The highest developments of this application are to be found in the New World, where the architectural characteristics are admirably suited to the purpose. The best example of this is in the new Empire State Building in New York, which embodies about 380 tons of light metal, in the form of store fronts, marquises, lift doors, observation towers, etc. On the top of this building, a steel tower over two hundred feet high is being built as a mooring mast for airships. The whole of this tower is to be sheathed in a 5% silicon aluminium alloy, which, in order to obtain the desired colour, will be frosted over its entire surface.

The great advantage of aluminium as an architectural material is its lightness. Although in bulk heavier than ordinary building stone and cement, it is used in the form of hollow castings, which are cheaper and easier to make than stone carvings. In the form most used for external purposes (a 5 to 10% silicon alloy), it has excellent qualities of resistance to atmospheric corrosion, for a film of aluminium oxide is formed over the surface which protects the metal from further action. The film produced is sufficiently thick to give a noticeable colour, which varies from a pure white with unalloyed aluminium to a dark effect on the high silicon alloys.

Considerable interest in this new departure has been aroused among British and Continental architects, and it is anticipated that aluminium decoration will soon become a feature of new buildings in this country.

Iron and Steel Report.

WHATEVER change has developed during the past month in the iron and steel markets has been a slight one for the better. In some sections of engineering inquiry has shown signs of broadening, and reports to this effect have come from Lancashire, the Sheffield district, and the North-East Coast. Up to the present, however, any improvement has been largely confined to the foundry iron section, with little, if any, expansion in steel tonnage placed by constructional engineers, shipbuilders, or locomotive builders.

Since early in March, sellers of foundry iron pretty well in every centre have booked only a very limited business. To some extent, and perhaps more especially in Lancashire, this was attributed to the fact that scrap material, much of it textile machinery scrap of good quality, was in plentiful supply, and obtainable at little more than half the price of foundry iron, the margin between the two being narrower than at any previous time. In addition, there has been in evidence among pig-iron users a marked lack of confidence in the stability of prices, and many of them have been restricting commitments.

The beginning of the present month witnessed a turn for the better. Besides sharing in the general improvement in sentiment subsequent to the Hoover declaration on war debts, foundry-iron sellers enjoyed the more practical experience of an increase in actual transactions. For the most part this seems so far to have applied more particularly to Lancashire, with a fair proportion of the increased business relating to deliveries over periods extending up to about three months ahead. Unfortunately, although one or two isolated instances are reported where textile machinery manufacturers had better order books, this is not the general experience in this branch of engineering, which comprises the biggest outlet for pig iron in the county. The spurt points as much to a renewal of confidence in the foundry iron market as to anything else, and as such should be welcomed. Scottish iron has eased off fractionally during the past month, but in all other respects this section has maintained a steady front.

The fact cannot be ignored, however, that fair-sized stocks of iron are held at most furnaces throughout the country, and whilst some of the leading producers are in the happy position of being able to absorb much of their production in associated foundries, others are finding them unwieldy, and plant has in consequence been damped down.

In finished iron, the relatively best situated section is still marked bars, and a moderate demand for these is reported from various centres. The crown bar mills, however, are finding the aggregate demand of small dimensions still, notwithstanding the recent substantial reductions in quotations. This is also the case with the nut, bolt, and fencing qualities, which has to meet serious competition from cheap foreign materials.

Steel rollers have found conditions little better than before, and in the principal heavy industries the demand has been much below normal, with orders in most instances confined to early rolling programmes. This latter feature, apart from the unsatisfactory state of the consuming industries, has also been largely dictated by a hope that makers at their July meeting might decide upon a reduction in the prices of controlled production. At the moment of writing, it is not known whether such a move has been made. The demand for special alloy steels has been spasmodic in character, although fair trade has been done.

The markets for Continental iron and steel products have latterly experienced a firmer tendency in virtually every section, after a prolonged spell of weakness. To no appreciable extent, however, has this resulted in an expansion of buying interests in this country. One important new feature in the Continental market is that supplies of semi-finished materials are less easily secured for early delivery dates, and firmness in respect of these has been fully maintained. This has not been so, however, with finished steels, and at the moment of writing renewed easiness seems to be developing.

Catalogues and Other Publications.

A recent brochure issued by Sir W. G. Armstrong Whitworth & Co. (England), Ltd., contains full details of some of the latest Armstrong Whitworth metal-melting furnaces. Among the types dealt with are printers' refining furnaces, general utility furnaces, non-ferrous metal-melting furnaces, and preheating furnaces, all for gas or oil-firing. The brochure contains illustrations and diagrams of the different types, as well as tables of melting times, fuel consumption, shipping particulars, etc. It may be obtained on application to the company's Scotswood Works, Newcastle-on-Tyne.

Messrs. Chapman & Hall, Ltd., of Henrietta Street, Covent Garden, London, W.C. 2, have sent us a copy of the new edition of the catalogue of the technical and scientific books published by Messrs. John Wiley & Sons, of New York, for whom Messrs. Chapman & Hall are agents. To assist in tracing any one of the 964 publications in this catalogue, there is an index of authors as well as an index of subjects; the actual arrangement is such that each subject has its own section, in which the books are arranged alphabetically according to the names of the authors.

A new brochure on "High Alumina Blocks for Rotary Cement Kiln Linings" has been sent to us by Algernon Lewis Curtis, refractory and clay specialist, of Westmoor Laboratory, Chatteris. It is divided into four parts: The first part discussing refractories other than high alumina block; the second describing these blocks; the third discussing their advantages; and the fourth giving "Hints on the setting of lining blocks." There are photographs and illustrations throughout, while a table at the end gives details of cupola shapes, rectangular shapes, key blocks, throat blocks, and double tapers. No pains seem to have been spared in making this catalogue useful to all cement-works engineers and those who have anything to do with rotary kilns.

Until recent years plumbing fixtures and fittings have generally been made of brass, either polished or nickel plated, and the frequent tarnishing of this metal has been regarded as unavoidable. But, since the introduction of corrosion-resisting ferrous and non-ferrous metals, great progress has been made in the production of bathroom fitting of all kinds. Of these alloys, nickel silver is perhaps the most satisfactory, and its use is increasing in every direction. The June issue of the *Nickel Bulletin* contains an article discussing this subject, and detailing many of the different applications of this alloy in hospitals, private houses, hotels, ships, offices, and on railways. A number of illustrations give the article additional interest. In addition this issue contains articles on "Nickel-Iron Alloys in Low Frequency Transformers," "*The Empress of Britain*," and "Solving a Screening Problem."

Among recent publications of I.C.I. Metals, Ltd., are two brochures, one dealing with the rods and sections products of their Witton Works, and the other with the "AE" products of their tube section, Kingston Metal Works, Smethwick. Both contain full details of the respective products, and a number of ilustrations give additional interest to the descriptions of the various manufacturing processes. Two illustrations in colour, in particular, show the remarkable contrast between "AE" condenser tubes and similar brass tubes, after a certain length of service. Several pages at the end of each brochure are devoted to tables of specifications, weights, temperature conversion tables, specific gravity etc.

Pipe Making by a New Method.

An interesting development in pipe-making has been started at Stockton-on-Tees, where the South Durham Steel and Iron Company, Ltd., are constructing steel pipes by the metallic arc process. A five-mile main of 15-in. pipe, at present being made for the Sunderland Gas Company, will have its joints welded *in situ*, and thoroughly tested by compressed air, the result being virtually a continuous main. The chief advantages of this process are that it gives greater strength and permits the use of thinner pipe than is used in the usual water gas welding process. The new equipment can deal with pipes from 15 in. to 100 in. in diameter, and up to 30 ft. in length.

MARKET PRICES

ALUMINIUM.

99% Purity	£85	0	0

ANTIMONY.

English	£34	0	0
Chinese	23	2	6
Crude	21	0	0

BRASS.

Solid Drawn Tubes	lb.	9½d.
Brazed Tubes	lb.	11½d.
Rods Drawn	,,	8⅞d.
Wire	,,	7⅞d.
*Extruded Brass Bars	,,	4⅜d.

COPPER.

Standard Cash	£35	0	0
Electrolytic	38	10	0
Best Selected	37	15	0
Tough	37	5	0
Sheets	70	0	0
Wire Bars	42	17	6
Ingot Bars	42	17	6
Solid Drawn Tubes	lb.		10½d.
Brazed Tubes	,,		10½d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	1	11½
‡Ferro Tungsten	,,	0	1	8½
§ Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
2-4% Carbon, scale 11/- per unit	ton	28	0	0
4-6% Carbon, scale 7/- per unit	,,	21	10	0
6-8% Carbon, scale 7/- per unit	,,	20	12	6
8-10% Carbon, scale 7/- per unit	,,	20	0	0
§ Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 10/- per unit	,,	30	10	0
Guar. max. 1% Carbon, scale 13/6 per unit	,,	34	7	6
§Guar. max. 0.7% Carbon, scale 15/- per unit	,,	37	17	6
‡Manganese Metal 96-98% Mn.	lb.	0	1	3
‡Metallic Chromium	,,	0	2	7
§ Ferro-Vanadium 25-50%	,,	0	12	8
§ Spiegel, 18-20%	ton	6	17	6
Ferro Silicon—				
Basis 10%, scale 3/- per unit	ton	5	17	6
20/30% basis 25%, scale 3/- per unit	,,	7	0	0
45/50% basis 45%, scale 5/- per unit	,,	9	17	6
70/80% basis 75%, scale 7/- per unit	,,	16	5	0
90/95% basis 90%, scale 10/- per unit	,,	24	17	6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	,,	12	12	6
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	6
Ferro Phosphorus, 20-25%	ton	15	10	0

FUELS.

Foundry Coke—						
S. Wales Export	£1	2	0 to	£1	16	6
Sheffield Export	0	14	0 to	0	15	0
Durham Export			1	4	0	
Furnace Coke—						
Sheffield Export	0	14	0 to	0	15	0
S. Wales ,,	0	16	6 to	0	17	6
Durham			0	13	0	

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£54	0	0
*Commercial Ingots	44	10	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0 10
*Cored Bars	,,	0	1 0

LEAD.

Soft Foreign	£12	16	3
English	14	5	0

MANUFACTURED IRON.

Scotland—			
Crown Bars	£10	5	0
N.E. Coast—			
Rivets	11	5	0
Best Bars	11	0	0
Common Bars	10	10	0
Lancashire—			
Crown Bars	9	15	0
Hoops	12	0	0
Midlands—			
Crown Bars £9 5 0 to	10	7	6
Marked Bars	12	0	0
Unmarked Bars		—	
Nut and Bolt Bars £8 10 0 to	9	0	0
Gas Strip	10	12	6
S. Yorks.—			
Best Bars	10	15	0
Hoops	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards	lb.	10d.
*Cored Bars	,,	1/-
†Strip	,,	11½d.
†Sheet to 10 W.G.	,,	11¾d.
†Wire	,,	1/0½
†Rods	,,	11½d.
†Tubes	,,	1/4
†Castings	,,	1/1

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	10	0
Foundry No. 1	3	13	6
,, No. 3	3	11	0
N.E. Coast—			
Hematite No. 1	3	3	0
Foundry No. 1	3	1	0
,, No. 3	2	18	6
,, No. 4	2	17	6
Cleveland—			
Foundry No. 3	2	18	6
,, No. 4	2	17	6
Silicon Iron	3	1	0
Forge No. 4	2	17	0
N.W. Coast—			
Hematite	4	4	6
Midlands—			
N. Staffs Forge No. 4	3	1	0
,, Foundry No. 3	3	6	0
Northants—			
Forge No. 4	2	17	6
Foundry No. 3	3	2	6
Derbyshire Forge	3	1	0
,, Foundry No. 3	3	6	0
West Coast Hematite	4	2	6
East ,, ,,	4	0	0

SWEDISH CHARCOAL IRON AND STEEL.

Pig Iron	£6	0	0 to	£7	10	0		
Bars, hammered, basis	£17	10	0	,,	£18	10	0	
Blooms	£10	0	0	,,	£12	0	0	
Keg steel	£32	0	0	,,	£33	0	0	
Faggot steel	£20	0	0	,,	£24	0	0	

All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£50	0	0
,, Braziery	27	0	0
,, Wire		—	
Brass	21	0	0
Gun Metal	26	0	0
Zinc	6	0	0
Aluminium Cuttings	52	0	0
Lead	8	5	0
Heavy Steel—			
S. Wales	2	0	0
Scotland	1	17	6
Cleveland	1	17	6
Cast Iron—			
Lancashire	2	5	0
S. Wales £2 2 6 to	2	5	0
Cleveland £2 2 6 to	2	4	0
Steel Turnings—			
Cleveland	1	5	0
Lancashire	1	0	0
Cast Iron Borings—			
Cleveland	1	2	0
Scotland	1	10	0

SPELTER.

G.O.B. Official		—	
Hard	£9	5	0
English	13	5	0
India	11	5	0
Re-melted	11	5	0

STEEL.

Ship, Bridge, and Tank Plates—			
Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	10	10	0
,, ,, (Marine) ,,	10	10	0
,, ,, (Land), N.E. Coast	10	0	0
,, ,, (Marine) ,,	10	10	0
Angles, Scotland	8	7	6
,, North-East Coast	8	7	6
,, Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	0	0
Light Rails	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £8 2 6 and	8	12	6
Medium Basic £6 12 6 and	7	2	6
Soft Basic	6	0	0
Hoops £9 10 0 to	9	15	0
Manchester—			
Hoops £9 0 0 to	10	0	0
Scotland, Sheets 20 W.G.	9	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 18% Tungsten	lb.	2/9
Extras		—
Round and Squares, ¼ in. to ½ in.	,,	3d.
Under ½ in. to ⅞ in.	,,	1/-
Round and Squares 3 in.	,,	4d.
Flats under 1 in. × ⅛ in.	,,	3d.
,, ,, ½ in. × ¼ in.	,,	1/-

TIN.

Standard Cash	£113	5	0
English	115	0	0
Australian	114	12	6
Eastern	117	15	0
Tin Plates I.C. 20 × 14 box	13/6 to 13/9		
Block Tin Cash	£114	2	6

ZINC.

English Sheets	£20	0	0
Rods	22	0	0
Battery Plates	16	10	0

* McKechnie Brothers, Ltd., quoted July 8. † C. Clifford & Son, Ltd., quoted July 10. ‡Murex Limited, quoted July 10.

Subject to Market fluctuations, Buyers are advised to send inquiries for current prices.

Lancashire Steel Corporation's Current Basis Prices, f.o.b. Liverpool or Stations in Lancashire :—Wrought Iron Bars, £9 15s. 0d.; Mild Steel Bars, £6 10s. 0d.; Wrought Iron Hoops, £11 10s.; Best Special Steel Baling Hoops, £8 5s. 0d.; Soft Steel Hoops (Coopers' and Ordinary Qualities), £7 15s. 0d.; C. R. & C. A. Steel Hoops, £11 10s. 0d. "Iris" Bars, £8 5s. 0d. All Nett Cash. Quoted July 10. § Prices quoted July 10, ex warehouse.